THURSDAY, MARCH 29, 1894.

THE FLOWERING PLANTS OF WESTERN INDIA.

The Flowering Plants of Western India. By Rev. A. K. Nairne. 8vo. pp. 401. (London: W. H. Allen and Co. Bombay: The Education Society's Press, Byculla.)

NOW that the "Flora of British India," by Sir Joseph Hooker and his helpers, is nearing completion, we are sure to get works more or less founded upon it, dealing with smaller areas which it includes. The first portion of Trimen's "Flora of Ceylon" has already appeared. This is a strictly scientific work, and a thoroughly complete enumeration of the plants of the island; and now we have the present volume, which is merely a popular account of the principal plants occurring within the Presidency of Bombay, excluding Sindh. The author, the Rev. Alexander Nairne, belonged to the Bombay Civil Service, and made, whilst resident in India, notes on the habit and character of the more striking plants, which he saw, together with their native names and uses. Previously to the present work the only special books on the same district were the "Bombay Flora," published in 1861 by Dalzell and Gibson (the latter the energetic Conservator of Bombay Forests), and the "Catalogue of Plants growing in Bombay and its vicinity," which was published by Mr. Graham in 1839. But one cannot omit reference to the names of Mr. Law and Dr. Stocks. Mr. Law and Mr. Dalzell worked the Concan Flora most ably and energetically. Mr. Law resided for many years at Tannah, near Bombay, and explored the Northern Concan; while Mr. Dalzell chiefly employed himself in the Southern Concan and adjacent province of Canara. Dr. Stocks officiated for Dr. Gibson during that gentleman's visit to Europe. He collected in Sindh, and, amongst other plants, gathered the curious *Gossypium*, which bears his name, the probable parent of all the forms of Indian cotton, and also in the mountains of the Concan, the small *Impatiens Stocksii*. Besides the books mentioned, many Bombay plants are described in Roxburgh's "Flora," and in Wight and Arnott's "Prodromus," and many are figured in Wight's "Icones." Mr. Nairne states that he knows the Concan fairly well, which, with the ghauts which bound it on the east, are botanically the richest part of the Presidency. He also claims a fair acquaintance with the Deccan, but he has never been in the Southern Maratta country at all, and his acquaintance with Guzerat is decidedly limited. The mode in which the scientific part of this book is made up is as follows: "The nomenclature and classification are entirely those of Hooker's 'Indian Flora'; the descriptions of orders are mainly Hooker's, but with details from other writers. The descriptions of genera are Hooker's, very much compressed"; so much compressed, we are afraid, as to be in some cases quite unintelligible. As has before been mentioned, the descriptions of species are from the author's own notes, compared with those of other writers, chiefly Hooker's and Dalzell's. The title appears to us decidedly misleading ("The Flowering Plants of Western India"), as one might naturally expect at least an enumeration of all the Phanerogamous plants growing within the Presidency, and this is far from being the case. What will Mr. C. B. Clarke, the talented monographer of the natural order *Cyperaceæ*, say when he sees that his especial *protégés* find no place in the Flora? *Gramineæ* are also omitted. Mr. Nairne states that their flowers "consist only of bracts or scales," and does not evidently consider these two orders sufficiently merit the rank of flowering plants. The book, we are told, is intended for two classes—"Firstly, the Englishmen and Englishwomen whose duty calls them to Western India, and who wish to know something about the trees and flowers which surround them; and secondly, the educated natives of the country." It is a small octavo, and can be easily carried for field work. The contents consist of a prelude of several pages of quotations, introduction, definition of terms used in the work, several pages to explain the system of classification employed, then the body of the work, and it concludes with a couple of indices—one for Latin and English names, and one for the native names. In the body of the work you first get a conspectus of the orders, then under each order you get a more amplified description, a short key to the genera, and then the species, for which no authorities are given, are described briefly in English. The less important species are described in smaller type, and a quotation is generally added from a well-known writer.

We are afraid much might be said in criticism of the work. Taking *Malvaceæ*, for instance, on page 27, we hardly think the generic characters are correct or sufficient. The diagnostic character applied to *Malva* is "Downy herbs, involucre of three distinct bracts," and the author evidently has not grasped the fact that the chief distinction between *Sida* and *Abutilon* is that in the one the carpels are uniovulate, while in the other they are multiovulate. We should also like to know why *Sida mysorensis* and *Sida cuneifolia* (*S. Schimperiana*) are omitted? A quotation from Le Maout is inserted, saying, "The plants of the order are all wholesome." We think the conspectus of the orders ought to be entirely revised, or almost rewritten. On page 138 we find a key to the orders of monopetalous Exogens. No primary division is based on the position of the ovary. Division (*a*), including *Plumbagineæ*, *Primulaceæ*, *Myrsineæ*, &c., is characterised by having "stamens 5, corolla regular," while division (*d*), including *Rubiaceæ* (except *Randia* and *Gardenia*), *Loganiaceæ*, *Boragineæ*, *Campanulaceæ*, &c. has "stamens 4 or 5, flowers regular." This is a distinction without a difference. *Compositæ* is not included in the conspectus, because "it is an order quite by itself with flowers composed of many distinct *perfect* florets." *Sapotaceæ*, *Ebenaceæ*, and *Styraceæ* are classed together as "trees, almost all with many stamens." We are left in doubt as to how we are to distinguish the one from the other; and here, as in several other cases, Mr. Nairne has shirked his responsibilities.

The Flora of the Bombay Presidency, as compared with that of the Nilghiris, is poor in forest types. The whole Concan is much more open than Malabar, and heavy forests are rarer, and many tropical Malayan forms disappear and are replaced by such plants as grow

on the east side of tropical Africa. It is said that in the northern province of Sindh, whose vegetation was first made known to science by Griffith, more than nine-tenths of the plants, on a rough estimate, are indigenous in Africa. At least one-half of these are common in Nubia or Egypt.

It is interesting to take for example the genus *Psychotria*, possibly the most difficult genus of the very large and difficult natural order to which it belongs. In Hooker's "Flora" there are 52 species, of which only 4 (Mr. Nairne has only 2) are found within the Bombay Presidency.

In conclusion, we may say that it is evident that the author has taken a good deal of pains over the book, but from a scientific point of view it is painfully incomplete as a conspectus of the plants of the district to which it relates.

THE PARASITIC THEORY OF THE CAUSATION OF MALIGNANT TUMOURS.

Cancer, Sarcoma, and other Morbid Growths considered in Relation to the Sporozoa. By J. Jackson Clarke, M.B.Lond., F.R.C.S. (London: Baillière, Tindall, and Cox, 1893.)

IT is perhaps not to be expected that in the present state of our knowledge of the relation of lower animal parasites to morbid growths any very definite opinion can be given on certain of the points raised in the small monograph now under review, and, especially, as to the accuracy of the opinions put forward. Indeed we imagine that many readers, after surveying with interest the arrangement and character of the work, will come to the conclusion that whether the theories advanced by the author are ultimately accepted or not, he has certainly not brought forward sufficient evidence in support of his thesis, and that had the energy and skill expended in polemical discussion and theoretical statement been brought to bear in carrying out more extended observations and the accumulation of facts, a very large amount of definite information might have been contributed to this very interesting subject. The interpretation put on the observations of others, and didactic assertion, can never be accepted in lieu of accurate observations, and a mere statement as to the inaccuracy of the work of the older observers, unless it is backed by prolonged investigation and accurate description, can never take the place of such older work.

After a careful perusal of the book now before us, and with the above reservations, we feel justified in stating that for those who wish to obtain a general outline of the subject treated, the abstracts and references given by the author will render this a comparatively easy task. As regards the original portion of the work, one cannot but feel that the author goes considerably beyond his proof in assuming that pathologists cannot obtain results similar to his—first of all, because they have not familiarised themselves with the newer methods of research, and secondly, because they have not "realised the protean characters of the sporozoa"; for, as the author himself points out, a large number of workers, some of them skilled histologists and trained biologists and pathologists, have been laboriously engaged in trying to set at rest some of the questions of which he so light-heartedly disposes, but with which no evidence of his own capacity to deal is offered in this original part of the work. In some cases the drawings certainly do not bear out the descriptions given in the text, whilst in others few observers will be able to accept the somewhat diagrammatic representations made to do duty as illustrations, as being anything more than familiar degenerative appearances seen through the eye of a somewhat partial observer. It appears to us to be a mistake for any one to try to make facts fit into theories; a far more profitable occupation is to make theories accord with facts. Again, some of the author's observations may be accepted as accurate in themselves, but it is difficult to see what bearing they have on the existence of a causal relationship between the lower animal parasites and malignant tumours. That some such relationship does exist is daily becoming more probable, but the evidence accumulated up to the present, in spite of the great amount of work that has recently been done, is still but scanty, and it remains for workers to follow out carefully and accurately the various "parasitic" forms that have been described, and to learn something more of their mode of origin, life-history, and ultimate destiny, before they can begin to build up elaborate theories on the relation of these organisms to morbid growths with any well-grounded hope that such theories will have anything more than an ephemeral existence.

OUR BOOK SHELF

The Fauna of the Deep Sea. By Sydney J. Hickson, M.A., D.Sc. (London: Kegan Paul, Trench, Trübner, and Co., Limited, 1894.)

THIS little volume forms one of the "Modern Science" series edited by the Right Hon. Sir J. Lubbock, Bart. It treats of a very interesting subject, which for the last twenty-five years has attracted the attention and engaged the service of many biologists. Great though the contributions of our American and French *confrères* have been towards its elucidation, yet the long series of splendid volumes of our own *Challenger* reports will stand as a proof of what this country has done in this direction; nor in writing this do we forget for a moment the fact that many of the *Challenger* reports were written by the sons of other nations besides our own. With these reports and those by Agassiz on the "Voyages of the *Blake*," our author certainly had abundance of material for his sketch of the subject, for he pretends to nothing more. He gives us a short history of the deep-sea investigations, going back some fifty years ago, to the time of Goodsir's haul in Davis Straits, to Dr. Wallich's bringing up star-fish from some 1260 fathoms of depth, and so till he tells of the as yet unfinished researches off the eastern slopes of the Pacific Ocean by the *Albatross*, and those in the Indian ocean by H.M. *Investigator*.

No doubt it was a difficult task to crowd into sixteen pages even a *précis* of such a mass of facts, and yet we think it might have been improved had the author looked into a volume, from which as far as we can judge he does not quote, by Wyville Thomson, on "The Depths of the Sea." The second chapter, on the physical conditions of the Abyss, is well written. Might not the pelagic algæ, which are sometimes to be found covering the surface for miles, play a more important part than is seemingly

ascribed to them as food for the deep-sea forms; though not weighted, like the radiolarians, diatoms, &c., with silex, still they might in time fall from the table of the upper waters on, or rather down, to that of the hungry deep-dwelling forms. In the chapter on the relations of the Abysmal zone and the origin of its fauna, the author introduces the new classification of the ocean fauna, "Plankton," "Nekton," and "Benthos," and he is good enough to write that though "it will not be necessary to use these terms very frequently in this little book, it may be advisable for the reader to bear in mind that in any exhaustive treatise on the marine fauna such terms would be used and employed." We, however, only find in the index one reference to them, and that the one we have just quoted; nor in the following chapter, treating of the characters of the deep sea fauna, does the author employ them, though here their use might have assisted the meaning. Perhaps this Greek armour was found too cumbrous.

The last paragraph of this chapter we would have preferred omitted. We cannot see the relevancy of Moseley in comparing the deep sea fauna, even "as a whole," as in any way similar to the flora of the high mountains. If some of the deep-sea forms are dwarfed, this is surely the exception, and giants of almost all the groups are to be found among them; whereas what gigantic representatives of any group are to be found on the mountain tops?

The remaining four chapters treat of the Protozoa, Cœlentera, Echinoderma, Vermes, Mollusca, Arthropoda, and Fish of the deep sea. They open with a regret that "although thousands of species of animals have been described in the volumes that have been devoted to deep-sea work, yet the number of the sub-kingdoms and classes remains the same," and conclude with a hope, in which we join, "that in the future there may be a new stimulus given to deep-sea research, and that the many unsolved problems may be again seriously studied and eventually solved."

A Treatise on Elementary Hydrostatics. By John Greaves, M.A. (Cambridge University Press, 1894.)

A BRIEF examination of this treatise is sufficient to allow us to form a favourable opinion of its contents. Nearly every proposition or description shows that the author is a thorough master of his subject, and, what is also of equal importance, can impart his knowledge to his readers in language both concise and fresh. The treatise is intended for those preparing for the first part of the Mathematical Tripos, and is different from other elementary works on the same subject in the following manner: In this Tripos examination one is now allowed to use the notation of the calculus, which for some students is a great boon, in that problems can be more easily solved, and in less time. We are thus presented in the text of this treatise not only with the usual proofs, but with alternative proofs when the use of the calculus is a distinct advantage. This alteration will be found an improvement. The definition of a fluid, from which are deduced the principles of the subject, is given as "a substance which will yield to any continued shearing stress, however small, or," in other words, "when a fluid is in equilibrium, the stress across any plane in it is entirely normal to that plane."

Among other useful additions to the subject may be mentioned propositions relating to a heterogeneous fluid in equilibrium under any system of forces, and some cases of simple motion, the latter of which may be left for a second reading. In chapter ix. the author deduces several well-known capillary phenomena from the experimental result that the energy of a material system depends to a great extent on the surfaces separating the different substances.

As the book is printed in clear type and contains neat diagrams, it will be sure to find favour with students.

LETTERS TO THE EDITOR.

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Sun-spots and Magnetic Disturbances.

The note in NATURE for February 22, 1894 (p. 397) concerning "Sun-spots and Magnetic Disturbances" illustrates most clearly the necessity for the adoption of a proper method in order to arrive at any conclusion respecting the relation between these phenomena. I must continue to insist, as I have done heretofore in the columns of NATURE and elsewhere, that the study of the periodicity of magnetic storms and auroras at intervals of about twenty-seven and one quarter days must precede that of the attendant solar conditions, otherwise no results will be obtained. For example, during the month of August 1893, to which the note above mentioned refers, sun-spots were so numerous that it would be utterly impossible to determine which group, if any, were in a location upon the sun capable of originating terrestrial magnetic effects. The proper way is to begin by disregarding solar conditions entirely, and arrange the magnetic storms or auroras of the period that it is desired to study, in series as they actually occurred at the twenty-seven and one quarter day interval. This being done, it is possible at a glance to determine what particular solar conditions reappear invariably when magnetic perturbations are recorded. In this way, and in this way alone, it becomes evident that whenever these magnetic effects appear, there is always a disturbed portion of the sun at the eastern limb and near the plane of the earth's orbit in that location. If the series of recurrences is sufficiently persistent to last through many solar rotations, it will be found that the disturbed area continues to have its effect in spite of considerable variations in the size of the spots, and that at times these effects may continue even when nothing but groups of faculæ remain, these being however, unusually bright and extensive in such a case. By following the history of such recurrences into the portion of the year in which any given disturbed portion of the sun is at a distance from the plane of the earth's orbit, when at the eastern limb, it is found that outbreaks of violent thunderstorms, which do not produce any disturbance of the magnetic needle, take the place of magnetic storms and auroras in the regular order of recurrence. There have been some phenomenal illustrations of this the past winter. Usually in this part of the United States a thunderstorm in winter is very rare, and, if it occurs, stands forth as a prominent event. Thus the thunderstorms of Christmas-day and night, in which buildings were struck by lightning in this State, were most exceptional, and, falling as they did upon the proper date to form the continuation of the strongest and most persistent series of thunderstorms and auroras that has been current the past year, were most striking. The above method of attacking the question is that which the writer has gradually developed for the purpose of systematic study. The relation having once been established by tracing the history faithfully and in detail, in the manner described, it is no longer absolutely essential to enter into the question of periodicity in order to secure evidence bearing upon the question. As soon as it is known what has to be looked for, it will only be necessary, when any very large increase of thunderstorms occurs, or any notable magnetic perturbations, as the case may be, to look at the proper part of the sun, and see whether it is the seat of disturbance. In this way it will be found that it is not the size of solar disturbances, but their activity at the critical date when they are in the proper location, that determines the terrestrial effects to which reference has been made. Thus it is a question throughout of the adoption of a proper method of investigation.

M. A. VEEDER.

Lyons, N.Y., March 12.

Dredging Expedition at Port Erin.

THE Liverpool Marine Biology Committee organised a dredging expedition from the Port Erin Biological Station at Easter. The party of a dozen naturalists included several members of the committee, Mr. I. C. Thompson, Mr. A. Leicester and Prof. Herdman, Prof. Weiss, Dr. Hurst, Mr.

Gamble, and Mr. Hick from Owens College, Mr. W. I. Beaumont, and Mr. E. T. Browne. The steam trawler *Lady Loch* was chartered for two days, and the weather was perfect for work at sea. On the first day, the sea-bottom to the north of Port Erin, from Fleshwick to Contrary Head at Peel, was explored at twelve stations ranging from quarter of a mile to four miles from the coast, and from depths of ten to twenty fathoms. On the second day the steamer coasted along the west side of Calf Island and about four miles further to the west, dredging at nine stations from one to four miles from land, and at depths of nineteen to twenty-five fathoms. Two series of samples of the bottom deposits brought up in the dredge were preserved, the one set for more detailed examination in the laboratory, the other for transmission to the Jermyn Street Museum, where the Director-General of the Survey is forming a series illustrating the submarine deposits of our coasts. Besides the more ordinary gravels, sands, and muds, several peculiar deposits occurred, one of which was almost entirely composed of the shells of *Pectunculus glycimeris*, while another, which looked like a coarse sand, was seen to be formed of the broken spines of *Spatangus* and other Echinoderms. In some places the bottom for considerable distances is covered with *Melobesia* and *Lithothamnium*.

The greater part of the material obtained has still to be examined in detail, and will be treated of in future reports of the Liverpool Marine Biological Committee. Among the more noticeable forms obtained were:—The massive state of *Cliona celata*, *Sarcodictyon catenata*, the Echinoderms *Antedon rosaceus*, *Palmipes membranaceus*, *Luidea savignyi*, *Stichaster roseus*, *Echinocardium flavescens*, *Cucumaria hyndmani*, *Thyone fusus*, and *T. raphanus*, *Cellaria fistulosa*, *Scalpellum*, *Tellina crassa*, and the Ascidians *Polycarpa comata*, *Engyra glutinans*, *Ascidia plebeia*, *Cynthia morus*, and a *Microcosmus* which seems an unknown form. Mr. Thompson and Mr. Browne worked townets both on the surface and also at the bottom attached to the dredge. Most of the crabs and other higher Crustacea were found to be spawning, and some of the Nudibranchs are spawning in the tanks at the Biological Station. A common anemone a few weeks ago produced about fifty young, which have now from twelve to sixteen tentacles.

Several of the dredging party are staying on to work at the Biological Station during a part or the whole of April, and another dredging expedition will be arranged by the committee at Whitsuntide. W. A. HERDMAN.

University College, Liverpool, March 26.

THE SCOPE OF PSYCHO-PHYSIOLOGY.

UNDER the title of psycho-physiology may be comprised those investigations in psychology which have explicit or tacit reference to the concomitant physiological processes, and which are characterised by the application of the experimental method. The boundaries of the subject are somewhat ill-defined, since it shades off into physiology on the one hand, and into introspective psychology on the other. I shall endeavour in this article to indicate the scope of such experimental investigations.

A chick, not many hours old, will peck with fair but not complete accuracy at any small object which catches its eye. Here we have a reflex and responsive action. A stimulus is received in a sense-organ; an impulse is carried centripetally along ingoing or afferent nerve-fibres; certain nerve-centres are thrown into activity; and an outgoing impulse is carried by efferent nerve-fibres to muscles which are thus thrown into co-ordinated activity. It is probable that, on the *first* occurrence of such an action, it is purely automatic and is performed in virtue of the possession, by the chick, of an inherited organic mechanism. It is accompanied by, but not guided by, consciousness. Such guidance, however, soon becomes evident. Throw to a chick two or three days old half a dozen caterpillars, some of them common "loopers," others yellow and black "cinnabars." In the absence of previous experience they will be equally seized. But the loopers will be swallowed, while the cinnabars will be dropped. Repeat the experiment next day. The loopers will be gobbled up at once. The cinnabars will remain almost, if not quite, untouched. An association has been formed between the sight and taste in the two cases. Consciousness is no longer merely an accompaniment of the action. It controls; enforcing the action in one case, inhibiting or restraining it in the other. It is probable that in the higher parts of the brain there are special centres, the physiological functioning of which is associated with this conscious control. Such activities of the chick, first those which are merely responsive and automatic, secondly those which are under conscious control, exemplify a wide range of activities both in animals and man.

Let us note the scope of the experimental work that they suggest. First, there is the nature and range of stimulation of the nerve-endings in the sense-organ. Secondly, there is the nature and rate of transmission of the impulses along the nerve-fibres afferent and efferent. Thirdly, there are the nature and localisation of the activities of the automatic centres, and the time occupied by their peculiar functioning. Fourthly, there is the physiological and psychological investigation of the nature and mode of origin of the consciousness which accompanies the movements of parts of the body during response. Fifthly, there are the conditions, psychological and physiological, of association. And sixthly, there is the mode of application of the control, and the localisation of specialised control centres, together with the estimation of the time-element in control.

All of these have been made the subject of careful and systematic inquiry by the method of experiment. In all cases such experimental investigation has led, if not to brilliant positive results, at all events to salutary acknowledgment of ignorance. Difficulties of interpretation abound. Nowhere are these difficulties greater than in the investigation of the physiology and psychology of colour-vision. Take a dozen individuals, and get them successively to indicate by means of the cross-fibres of the spectroscope how far they can see along the spectrum, first in the direction of the extreme red, then in the direction of the extreme violet. You will find marked differences. Perhaps one will show a quite unusual amount of variation, and you will probably find by other tests that he is colour-blind. Is this variation in the retina or in the visual centre of the brain? It is well known that the psycho-physiology of vision is still a matter under discussion. One of the difficulties seems to arise from the fact that what is physiologically complex is psychologically simple. Purple gives a simple psychological sensation; but it is due to a combination of physiological impulses, the coalescence or synthesis of which is, so to speak, below the threshold of consciousness. One cannot, or I cannot, psychologically analyse purple into its constituents, as one can analyse a musical chord. There is still a wide field for research in the psycho-physiology of sensation.

An important line of investigation, which has now been followed up for many years, deals, not with differences of kind or of quality in sensation, but with variations in intensity. Given a stimulus which excites sensation; now diminish it, on the one hand, until it ceases to excite sensation, and increase it, on the other hand, until it reaches a maximum of sensation. Then formulate the law which shall express the relation which increase of stimulation bears to the increase of sensation. The results of Weber's researches went to show that we must look not to the absolute, but to the relative increments of stimulus; and Fechner, extending and generalising Weber's results, formulated the law of the relations thus:—When the stimuli increase in geometrical progression, the sensations increase in arithmetical progression, or the sensation is proportional to the logarithm of its stimulus. Concerning this law, the exactitude and range of its applicability, and its philosophical *raison*

d'être, there has been much animated discussion, into which I do not propose here to enter. Suffice it to say that if we represent by a curve the rise of sensation from the threshold where it first dawns, to its maximum, the law seems to hold good only for the mid-region. Various methods of experimentation are employed. Weber and Fechner employed chiefly the method of tabulating the just discernible differences in sensation, of increasing, that is to say, the intensity of the stimulus, and noting when this increment is just perceptible. Others, using larger intervals, have employed the method of estimating equal increments. Others, again, have constantly doubled the stimulus and noted the change in sensation. In all cases it must be remembered that what we are really dealing with is the perception of the relations between certain given sensations. This is a fact too often lost sight of. We have to infer from these relations the intensity-curve in sensation.

In addition to experimental investigations concerning the qualities and intensities of sensory elements in consciousness, there are others which deal with the feeling-tone, that is, the pleasurableness or painfulness of the sensation. Here with increase in the stimulus there is a rapid culmination of tone to the pleasurable maximum, after which it falls off pretty rapidly, and further increase gives rise not to pleasure, but to pain.

Researches on the rate of transmission of impulses along the afferent and efferent nerves may be regarded as mainly physiological. Suffice it to say that the rate is about 120 feet per second for ingoing impulses, and about 110 feet per second for outgoing impulses. Transmission in the spinal cord appears to be less rapid.

The results of experimental investigations on the localisation of function in the brain appear to justify the hypothesis that the automatic centres—or the centres concerned in merely organic response—are quite distinct from the control-centres, which are probably restricted to the cerebral cortex. It is a good working hypothesis that the centres which minister to control are the seat of those molecular disturbances which are concomitant with consciousness. Consciousness apart from control would be a mere epi-phenomenon of no practical use to the organism. It is scarcely necessary for me to do more than remind the reader of the conspicuous success which has crowned the efforts of those who have patiently and systematically applied the experimental method to the localisation of the centres of motor control. The motor regions of the hemispheres have now been mapped out with considerable exactitude. The centres of motor control in this region would seem to play down, so to speak, along the specialised channel of the "pyramidal tract," upon the lower automatic centres enforcing or inhibiting, as the case may be, their activity. They would seem to be developed on a secondary arc—the arc of control—superposed upon the lower reflex or responsive arc with its automatic centres. Sensory centres in this arc of control would seem to be, as might well be expected, less definitely restricted in position, as they are also more difficult of investigation. In all this field of research, as in the transmission of impulses, we are experimenting more on the physiological than on the psychological side of psycho-physiology.

When we come to association, very little that is exact and assured is known of the physiological aspect. It is said that association tracts—that is, groups of fibres connecting together the several centres in the cerebral cortex—are almost, if not quite, absent at birth, and are established during the development of experience, which may well enough be so; but what may be the physiological conditions of their development, we can at present only guess. On the psychological side much has been written on association; and in recent times Mr. Francis Galton, followed by Trautscholdt and others, have carried out experiments with the object of estimating the time that elapses between the reception of a simple impression and the occurrence of a simple idea suggested thereby. Such time would seem to be about three-quarters of a second.

Much attention has been paid to what is termed "reaction time"; that is, the time which elapses between a given simple stimulation and the resulting responsive motion. This was found by Lange to vary according as the person who is being tested directs his attention to the expected sense-impression or the anticipated motor response. In the case of a simple response to a visual stimulus, the reaction time in the former case is rather more than one-fourth of a second, but in the latter case only about one-sixth of a second. Practice tends to shorten the time, while fatigue lengthens it. A premonitory signal just before the stimulation markedly shortens it. Other experiments have been conducted with a view to ascertaining the time taken in simple cases of discrimination. This, too, varies very much with practice; and it is questionable whether the shorter time-values measure an act of discrimination properly so called. This part of the subject is full of difficulties in the interpretation of the results obtained.

In the Harvard psychological laboratory interesting researches have recently been carried out under the direction of Prof. Münsterberg. One of these deals with memory. Experimental results seem to show that a series of presentations offered to two senses at the same time, *e.g.* to sight and hearing, is much more easily reproduced than if given only to sight or only to hearing—a fact of educational value. Another series of experiments deals with the effect of attention. The unexpected result is reached that all stimuli appear relatively less when the attention is from the outset directed to them, as compared with stimuli received while the attention is otherwise occupied, *e.g.*, with simple addition sums. This result and the methods employed in the investigation are likely to undergo criticism.

Enough has now been said to indicate the kind of work on experimental lines which is being done in psycho-physiology. In England, while valuable researches have been prosecuted in cerebral localisation, comparatively little has been done on the lines which are followed up in the German and American psychological laboratories, though Mr. Francis Galton's valuable psychometric observations have been based on somewhat similar methods. I think that this is a matter for regret. It is true that both methods and results need perfecting and clarifying. That is generally so in pioneer work. It is true that it is mainly to elementary and simple psychological processes that the methods are applicable. But we must begin with the simple, however desirous we may be of reaching a knowledge of the complex. It is true that such experimental work cannot take the place of introspective observation. But may it not be used to supplement the older method? English psychologists have done such good work on the old lines, that one could wish that the newer methods should be given a fuller and more extensive trial. Somewhat is indeed being done, and there are signs of improvement. We need also systematic work in zoological psychology. Observations which I have made on newly-hatched chicks and ducklings, stimulated thereto by suggestions from my friend Mr. T. Mann Jones, have convinced me that there is a wide field for careful experimental work on the instincts and the dawning phases of intelligence in young animals. We must employ the experimental method if we would make further advance in the study of the mental faculties of animals. Is it too much to hope that the time is not far distant when there shall be established in England chairs of zoological and experimental psychology, the occupants of which shall have the direction of adequately equipped laboratories wherein systematic observations, on the lines I have above indicated, may be conducted?

C. LLOYD MORGAN.

THE BEHAVIOUR OF LIQUIDS UNDER HIGH PRESSURES.

ONE of the most important generalisations which has been obtained in recent years from the study of the effect of temperature and pressure on the volume of stable liquids and gases may be expressed by the law that if the volume of a given mass of substance be kept constant, increase of pressure is proportional to increase of temperature. This relationship was proposed as early as 1878 by Lévy, who was indeed anticipated to some extent by Dupré in 1869, but was first set upon a firm experimental basis, at least for vapours, by Ramsay and Young in 1887. They represent it algebraically by the equation $p = bt - a$, in which p is the pressure, t the temperature, and b and a are constants which vary with the volume and the chemical nature of the substances employed, and the curve corresponding to this equation they term an isochor. The law may therefore be shortly expressed by stating that for stable substances the isochors are straight lines. This generalisation leads, as Fitzgerald has shown, to the significant conclusions that specific heat at constant volume must be a function of the temperature only, and internal energy and entropy must be expressible as the sum of two functions, one of which is a function of the temperature only, and the other a function of the volume only.

The experiments of Ramsay and Young extend at most over a pressure range of about 100 atmospheres, and it thus becomes a matter of considerable interest to ascertain if the linear isochor still persists under pressures which are very much higher, especially when the substances operated upon are liquids at temperatures which are well below their critical temperatures. Important data on this point may be gleaned from Nos. 92 and 96 of the *Bulletin* of the United States Geological Survey, wherein are grouped together accounts of the varied researches carried out during the last few years by Mr. Carl Barus on several of the high pressure phenomena of liquid substances

His earlier work (*Bulletin* 92), completed in 1889, dealt with the isothermal compressibility of some fourteen liquids at temperatures and pressures having values as high as 310° and 600 atm. respectively—the pressure range being thus six times as great as that employed by the English observers.

From the data obtained, isochors[1] were eventually deduced with the result that, although below 180° they pursued a linear course, above this temperature under the high pressures employed they gave definite indication of being curved. To test by careful experiment over still wider ranges of pressure, this important question of curvature is the object of the later observations of Mr. Barus, which are detailed in No. 96 of the *Bulletin*.

The principle of the method there described consists in keeping the volume of the substance constant, and directly measuring the pressures which it supports at different temperatures, and thus obtaining immediately the data necessary for plotting the isochors. A new compression pump was devised, by means of which the enormous pressures of 2000 or 3000 atm. could be exerted. The temperature range was similar to that of the previous experiments, and the substances operated upon were ether, alcohol, thymol, pura-toluidine, and diphenylamine.

The results thus obtained pointed conclusively to the fact that at high temperatures and high pressures the isochors of the liquids employed are really curved. In general the linear isochor persisted up to pressures of 1000 atm., and over temperature ranges which varied with the nature of the substance, the maximum temperature being about 115° in the case of ether, and 65° in the case of diphenylamine for the volumes used. These volumes, it may be mentioned, were not measured, so that no stress can be put upon the absolute slopes obtained for the curves. In all cases but that of thymol, the deviation from the straight curve was a marked abrupt phenomenon, and occurred generally between 1000 and 1500 atm. Thymol, however, gave no appreciable deviation.

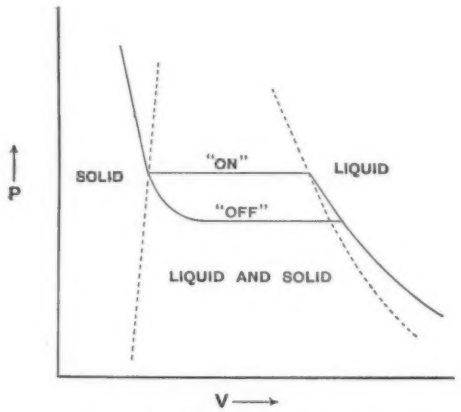
What this curvature may mean is as yet but a matter for speculation. The author inclines to the belief that it indicates a change of molecular state, and evidence into which he does not enter may be taken to point to the same conclusion. Ramsay and Young's work on dissociating gaseous substances like nitrogen peroxide and acetic acid has shown that during the progress of molecular decomposition curved isochors are obtained, which apparently bridge over the gap between the linear isochors corresponding with the simple and complex molecular states. If a like explanation applies to the liquids at present under consideration, it leads to rather a curious result, for the curvature of the isochor for alcohol is in the opposite direction to that of the isochors for all the other liquids. It would therefore follow that under increasing pressure at constant volume the alteration of the molecular state of alcohol is in the opposite sense to that of all the other liquids, and the observed direction of curvature favours the view that the liquid alcohol molecule eventually becomes simpler, while those of the other liquids become more complex. Such a condition of things may the more readily be conceived when it is borne in mind that the general physical behaviour of alcohol, and more especially its behaviour with regard to surface energy, indicate that under ordinary conditions it probably contains molecular aggregates, the complexity of which alters as the temperature alters. A liquid like ether, on the other hand, seems to contain under ordinary conditions simple gaseous molecules. The above results would thus have the interpretation that, volume remaining constant, the complex molecule of liquid alcohol corresponding with the origin of the isochor remains of the same degree of complexity over wide ranges of pressure until in the region of high pressures it becomes less complex; whereas the simple molecules of a liquid like ether, under the same conditions, eventually become associated into more complex aggregations. Of course, until more data have been accumulated, the above explanation must be regarded as but a conjecture; indeed, any definite reason why the molecular complexities of liquids like alcohol and ether should be so different, under ordinary conditions, is at present entirely wanting. Whatever happens, the significant observations here considered have definitely shown that the law of linear isochors, although it is valid throughout wide variations in the external conditions, eventually breaks down in the region of high pressures and high temperatures.

No less striking results are obtained by Mr. Barus on the effect of pressure in solidifying a liquid. Here he studies the volume changes produced by pressure during the solidification and fusion of naphthalene at various constant temperatures, and he is thus enabled to plot several of the isothermal lines for liquid-solid naphthalene between the temperatures of 60° and 130°, and between the pressures of 40 and 1700 atm.

The remarkable result arrived at in this way is, that during change of state the "on" curve obtained by increasing the pressure and passing from liquid to solid is quite distinct from the "off" curve obtained on passing from solid to liquid. At any temperature solidification always occurred at a higher pressure than that at which the solid fused. This is, of course, in harmony with the well-known fact that the temperature of the ordinary melting point of a substance is in general higher than its temperature of solidification.

[1] Instead of isochor, Mr. Barus uses throughout his papers the term sometric, originally proposed by Willard Gibbs.

The curious cyclic shape of the isothermals is diagrammatically indicated in the figure, which also brings out another difference in the processes of fusion and solidification. For when the liquid begins to solidify there is a sharp angle in the curve, solidification being an abrupt phenomenon. When the solid melts, however, there is no such sharp angle, the inclined portion of the isothermal gradually curves round and merges into the horizontal portion which represents the condition of the substance when fusion has actually set in. By repeated tests the author satisfied himself that this curvature of the isothermal was not the result of imperfect experiment, but indicated a real condition of the substance, and it may therefore be taken to correspond to a portion of the continuous curve originally proposed by Prof. James Thomson to express what actually goes on during isothermal change of state, and which is predicted for liquids and gases by the equations of van der Waals and of Ramsay and Young. From a general survey of the isothermals obtained, it appears that the volume at which solidification begins, decreases, and the volume at which it ends remains constant, or perhaps slightly increases as temperature rises. These facts are indicated by the



General shape of a Liquid-solid Isothermal.

dotted lines in the figure. We are thus enabled to map out a diagram for solid-liquid in precisely the same way as for liquid-gas, and arrive at the conclusion that at sufficiently high temperatures and pressures we shall reach the solid-liquid critical point. As far as the present experiments go, this point lies in the region of pressures above 4000 atm. and of temperatures higher than 200°. When the critical point is reached, the observations also show that the cyclic character of the isothermals will disappear. There will be no "volume lag" during fusion.

This "volume lag" the author regards as but a special case of hysteresis, having, besides its electrical and magnetic analogues, its counterpart in the phenomena of supersaturation, and the occurrence of all such phenomena he attributes to changes of molecular state. That a similar change lies at the root of the phenomena of solid-viscosity is the aim of a special series of investigations by Mr. Barus, which are collected in No. 94 of the *Bulletin*. The results obtained, however, are beyond the scope of the present article.

The main importance attaching to this work on naphthalene lies in the fact that it constitutes the beginning of a systematic study of the phenomena of solidification, which in conjunction with what is known regarding liquefaction, will ultimately permit of the entire transition from gas to liquid and from liquid to solid being represented on a single diagram. When this has been accomplished, material will be to hand for framing a comprehensive theory of what goes on during the obscure processes of change of state. Enough has already been done to give some idea of the extent to which the complexity of an equation like that of van der Waals, which involves but the third power of the volume, must be increased when attempting to express the complete passage from gas to liquid and from liquid to solid.

J. W. RODGER.

NOTES.

IT is announced that an International Electrical Exposition will be held in Paris from July 1 to October 31, 1895.

DR. W. HAVELBURG has been appointed director of a laboratory recently established at Rio de Janeiro for the study of leprosy.

THE death is announced of Dr. L. Calderon, Professor of Chemistry in Madrid University, and of Dr. Karl Schmidt, Professor of Chemistry in Dorpat University.

WITH reference to the brief notice of the death of Mr. W. Pengelly, F.R.S., in our last number, Mrs. Pengelly points out to us that "he was spoken of as Secretary, instead of Honorary Secretary, of the Torquay Natural History Society, a title of which he was naturally and reasonably jealous, seeing that his connection with the Society was always of a donative, and never of a receptive, character."

MR. F. MOCKLER'S collection of relics of Dr. Jenner, recently exhibited at Bristol, is now on view at the First Avenue Hotel, Holborn. Admission to the exhibition is free to all members of the medical profession. A movement is on foot to purchase the relics as a whole by public subscription, and to offer them to the Royal College of Surgeons.

SIR PHILIP CUNLIFFE-OWEN, whose death occurred on Friday last, at the age of sixty-six, played an important part in the development of the Department of Science and Art. In 1857 he was appointed Deputy-General Superintendent of the South Kensington Museum, and three years later he became Assistant Director. He succeeded Sir Henry Cole as Director of the Museum in 1873, and held that position until last year, when he retired. He did much to organise the collections at South Kensington, and in the Bethnal-green Museum, of which he was also a Director. His ability to organise, and great energy, led to his appointment as executive commissioner on a number of exhibitions of the works of science and the arts, and for these labours, numerous British and foreign orders were conferred upon him. Though not a man of science, he claims our esteem for the many things he did to advance scientific interests.

THE British Museum has recently acquired a section of a trunk of *Sequoia gigantea* from California, having a diameter of somewhat over 15 feet. The annual rings have been carefully counted by Mr. Carruthers, and, two years ago, when the tree was cut down, it was 1330 years old. It was then still living and vigorous. It had, therefore, already attained a considerable age when St. Augustine introduced Christianity into Great Britain. The rings indicate a remarkably symmetrical growth on all sides of the tree. For the first five or six centuries they show a considerable annual increase in the girth of the trunk, getting gradually thinner as the superficies to be covered became larger, and becoming very thin for the last three or four centuries. It is satisfactory to learn, on the authority of Mr. Carruthers, that there were, in 1884, in all the groves which he visited, trees of various ages, so that the *Sequoia* is in no danger of early extinction.

THE committee appointed by the Council of the Royal College of Surgeons of England to state conditions for giving effect to the proposals of Mr. Charles Clement Walker for the foundation of a prize with a view to the encouragement of the investigation of cancer have, says the *Lancet*, recommended the adoption of the following regulations:—(1) The prize shall be awarded for the best work in advancing the knowledge of the pathology and therapeutics of cancer done either partially or wholly within the five years preceding the year in which the prize shall be awarded; (2) the first award shall be for the period ending December 31, 1895, after which the prize shall be awarded quinquennially; (3) the prize shall consist of £100 except on the first occasion, when it will be £60; (4) the prize shall be awarded at the quarterly meeting of the Council in the April immediately following the termination of each period, and will not be awarded unless the committee appointed to judge shall consider some work deserving of it; (5) the committee shall consist of five members chosen by the Council, but not of necessity members of the Council, and they shall be appointed not less than one year prior to the date of the award of the prize; (6) the grounds upon which the prize is awarded shall be made public; (7) the prize shall be open to foreigners as well as British subjects, members of the Council of the Royal College of Surgeons alone being debarred from competition.

IN order to determine the heights of the highest cirrus clouds, only two methods have as yet been successfully attempted, namely, the measurement of altitude and azimuth by two or more observers some distance apart, and the determination of the exact time at which clouds are first seen illuminated by the morning sun, or last seen by the setting sun, coupled with which should be an approximate determination of the altitude and azimuth of the cloud. Prof. Cleveland Abbe gives an account of an observation of the latter kind in the U.S. *Monthly Weather Review*. On December 16, 1893, at 5.30 a.m. an observer at Potosi, Missouri, saw in the sky nearly overhead a bright redness of a tint like that of the rising sun. The phenomenon, which lasted for about fifty seconds, was not caused by a comet or meteor, nor was it auroral light, but was evidently the illumination by the sun's rays of a high, delicate cirrus cloud. The time of observation was about 1 hour and 40 minutes before sunrise, and allowing for the refraction by the air, it was found that if the cherry-tinted rays of the sun were at that time to illuminate a cloud in the position seen by the observer at Potosi, the cloud must have had an altitude of at least ten miles. Prof. Abbe remarks that in the clear sky of the early morning, and especially in the dry weather of summer, observers will be surprised to find how very early in the morning these delicate clouds may be observed, whence it follows that they must be correspondingly high, in fact, at latitude 52°, and on the 20th and 22nd of June they are reported to have been seen at midnight, when the sun is only 15° below the northern horizon.

Himmel und Erde for February contains an important lecture on cloud-formation, by Prof. W. v. Bezold. He discusses at some length the three principal causes of clouds:—(1) loss of heat by contact with the cold surface of the earth or sea; (2) mixture of unequally heated masses of air at or near the point of saturation; (3) expansion of air owing to change of pressure without sufficient increase of heat; and he illustrates each case by simple experiments. The paper contains some good representative pictures of clouds from photographs taken by Prof. Riggenbach and Dr. Neuhauss; and attention is specially drawn to certain wave-clouds not included in the classifications, but which Prof. v. Helmholtz has shown must occur by the passage of one stratum of air over another of different density, similar in all respects to the waves caused by the wind passing over a cornfield, or over the surface of the water. These clouds become visible when the two strata of air possess sufficient humidity; they occur at very different heights, although they appear to belong more to the middle and higher regions of the atmosphere than to the lower. When they are high enough for several of them to be seen at one time, they form the cirro-cumulus cloud, or mackerel sky. Two pictures of these clouds are given in the text.

WE learn from the *American Meteorological Journal* for March, that the papers read at the Chicago Congress of Meteorology, Climatology, and Terrestrial Magnetism, held last August, are to be published by the United States Weather Bureau in several parts, corresponding to the different sections of the Congress. The first part is nearly ready, and the remaining ones are expected to appear shortly.

THE island of Sakhalin, in the extreme east of Asia, remains one of the least known regions of the Western Pacific, partly, it is probable, because of its use by the Russian authorities as a penal station reserved for the worst offenders, to which outsiders are rarely admitted. In the new number of *Petermanns Mitteilungen*, F. Immanuel gives an admirable epitome of the geography and the present condition of the island, collected from the most recent Russian authorities and illustrated by a map. The mountainous northern interior of Sakhalin is still practically unexplored, but the southern and middle portions are fairly well known. The island has mineral resources of considerable importance, over two million tons of coal having been raised at Dui in 1890. The climate is changeable and ungenial, rain or snow falling on more than half the days of the year, and snow more frequently than rain. The population in 1891 was estimated to include 16,400 Russians and 3200 natives, the latter being mainly Gilyaks (1700) in the north, and Ainu (1100) in the south.

FROM a note in *Insect Life* it appears that attempts are being made to introduce an effective system of quarantine against injurious insects in California. The State is now importing fruits, trees, shrubs, plants, and seeds from Europe, Australia, China, Japan, South Sea Islands, South and Central America, and other localities, and hardly a vessel arrives at its ports which does not bring such objects, many of which are infested with some insect or fungus pest. At the Cape of Good Hope a quarantine law is in operation giving the Governor the power to provide by proclamation for protection against the importation and spread of pests, and providing a heavy penalty for its contravention. It is proposed to adopt similar legislation in California, and if the State succeeds in making its measures in this direction effective, its example will in all probability be widely followed.

THE relation of the sounds of fog signals to other sounds forms the subject of an important paper contributed to *Science* by Charles A. White, of the Smithsonian Institution. The areas of inaudibility which occur well within the range of most, if not all, the fog signals which the various civilised governments have established along their coasts, usually in connection with a lighthouse, are of two kinds. For the first kind the author suggests the name of *montumbral* areas, since they are true acoustic shadows cast by mountain ridges or islands within the range of the signals. The other kind, which is found in the open sea, and whose origin is not yet understood, he proposes to call *pseudumbral*, since they imitate the phenomena of acoustic shadows. There is, however, one important difference. From experiments performed at Sandy Hook upon a pseudumbral area it appears that sounds such as that of a steamer's

whistle were audible at the lighthouse when proceeding from a point within the area, whilst the fog signal itself was inaudible on board the steamer. This would indicate a peculiar one-sided action of the boundary of the area, or a differential effect upon the two kinds of sounds. Another peculiarity of these areas of inaudibility is that they do not annul sounds except those coming in a particular direction. Thus a vessel may be in a montumbral area with respect to a fog signal. A schooner with all sails set and close-hauled may be proceeding outside this area in such a manner as to produce a sail-echo of the fog signal audible on the first vessel. The signal will then appear to those on board to come from the direction of the schooner. Of the two kinds, the pseudumbral areas are the more dangerous, since their place is never quite fixed, and they can only be discovered and mapped empirically—in the present state of our knowledge, at all events.

THE current number of the *Electrician* contains a note by Prof. Fitzgerald on a recent paper of Herr P. Lenard's, which appeared in *Wiedemann's Annalen*. Herr Lenard has continued his interesting observations on the cathode rays in gases under ordinary pressures and in extreme vacua. In the experiments with high vacua, exhaustion was carried on till a coil, capable of giving a spark 15 cm. long in air, could not produce any discharge between terminals sealed into the experimental tube. Herr Lenard estimates that, when he had condensed the mercury vapour in a connected globe by lowering its temperature to $-21°$ C., the pressure of the remaining gas was about $0{\cdot}03 \times 10^{-6}$ of an atmosphere, or about 0·03 dyne per square centimetre. In a tube in which the exhaustion had been carried to this extent nothing was visible on the path of the rays except where they impinged on the glass at the opposite end of a tube 150 cm. long, and when there were no magnets near, they were propagated in straight lines. From these and many other interesting observations Herr Lenard concludes that the cathode rays are phenomena in the ether, and are independent of the presence of matter. With reference to this point Prof. Fitzgerald says :—"If this be so they are a most remarkable addition to the properties of the ether. Phenomena that may all be classed under light propagation are the only known phenomena of propagation in free ether. There is a very essential difference between these cathode rays and ordinary light propagation, and only for this these rays might be very rapid ultra-violet waves, which are known to be rapidly absorbed by air and other gases, but which may be able to run the gauntlet of hundreds of thousands of molecules without being finally absorbed, and might, in accordance with the known transparency of gold leaf, be able to penetrate any solid, even though a conductor, because for their extremely rapid vibrations the molecular motions upon which ordinary conductivity depends may be much too slow to have any sensible effect. The fact that seems conclusive against this view is the deflection of the rays by a magnet. These rays are deflected in the same way as a conductor carrying a current of electricity away from the cathode. No such action has ever been observed on rays of light. It would be most natural to explain the action by the presence of the matter which is generally required in order to be acted upon by a magnet. There seems very little reason for supposing that a magnet would act upon electric displacement currents in the ether, even if displacement currents of the straight ray kind were possible in the ether without propagating themselves out sideways with the velocity of light. When we recollect that in the vacua described by Herr Lenard there are still 10^{10} molecules per cubic m.m. there does not seem sufficient reason for looking to an unknown property of the ether when there is so much matter present to explain the phenomenon."

PROF. KAYSER AND RUNGE'S seventh paper on the spectra of the elements, communicated to the Berlin Academy of Sciences in December last, has been published in separate form. The elements of which the spectra are described in the paper are tin, lead, arsenic, antimony, and bismuth. In the case of the spectrum of tin the lines extend from wave-length 2053·8 to 5631·91, and fourteen lines are marked as new. The spectrum of lead was investigated between λλ 2088·5 and 6002·08, and thirteen new lines were discovered. Lines are tabulated for arsenic from λ 2009·31 to λ 3119·69. The antimony spectrum is limited by a line at 2068·54 in the ultra-violet, and one at 5730·52 rn the red, seven new lines being included. Bismuth has had its spectrum observed between the wave-lengths 2061·77 and 5742·74, and twenty-two new lines have been discovered. At the end of the paper the authors discuss the distribution of the lines and groups in the different spectra, and show that the positions admit of being determined mathematically.

THE behaviour of the filtrate from tetanus cultures when exposed to sunshine is perhaps the most interesting of the numerous observations made by Fermi and Pernossi. Already in 1891 Kitasato tested the pathogenic properties of tetanus filtrates obtained from broth cultures kept in the dark and light respectively, and found that exposure to diffused light gradually rendered them innocuous; it was, however, a very slow process, for even after from nine to ten weeks the filtrate was still feebly toxic. On the other hand, similar filtrates preserved in the dark were still, after 300 days, just as actively pathogenic to animals as when they were originally prepared. In direct sunshine (35°–43° C.), however, such filtrates were rendered perfectly harmless in from fifteen to eighteen hours. On the other hand, Fermi and Pernossi found that the toxic properties were destroyed after from eight to ten hours of sunshine during which the maximum temperature reached was between 38°–41° C., whilst when similarly exposed, the temperature, however (owing to the experimental tubes being immersed in water), not rising beyond 37° C. it required fifteen hours to produce the same result. When, however, the filtrate was first dried and then exposed to sunshine, it remained toxic even after 100 hours' insolation, the same results being obtained when the desiccated filtrate was mixed with chloroform, ether, benzol, and amyl alcohol respectively, and exposed to sunshine. The elaborate nature of the experiments, as well as the large number undertaken and the conscientious care with which they have been conducted, combine to render this one of the most important memoirs which has been yet published on the subject of tetanus.

A FURTHER illustration of the singular media in which fungi will thrive is afforded by the observation of M. Heim, recorded in the *Bulletin* of the Société Mycologique de France, of an abundant fungus-mycele in a solution of sulphate of quinine. It produces a fructification which shows that it belongs to the genus *Aspergillus*, and M. Heim proposes for it the name *Aspergillus quininæ* sp. n. (?).

THE annual report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the institution to July 1891, has just reached us. The volume contains an appendix comprising a selection of miscellaneous memoirs of interest to collaborators and correspondents of the institution, teachers, and others engaged in the promotion of knowledge.

WE have received parts i. and ii. of the thirty-seventh volume of the *Transactions* of the Royal Society of Edinburgh, and vol. xx. (pp. 97–160) of the *Proceedings*. Among the investigations described in the volumes we note the work of Prof. Crum Brown and Dr. James on the electrolytic synthesis of

dibasic acids; of Prof. Tait on impact; of Mr. Aitken on the particles in fogs and clouds; of Dr. John Murray on the chemical changes which take place in the composition of sea-water associated with blue-muds on the ocean floor; and of Dr. Pole on colour-blindness. Prof. Copeland's paper on Nova Aurigæ is included; and also that of Prof. Knott on circular magnetisation; of Prof. Ewart on the lateral sense-organs of Elasmobranchs; of Prof. James Geikie on the glacial succession in Europe; of Dr. Noël Paton on the action of the valves of the mammalian heart; and of Dr. Macfarlane on the minute structure of plant hybrids in relation to that of their parents.

RATHER more than one hundred years ago Christian Konrad Sprengel gave to the world his investigations on flower-fertilisation. The acute observations contained in "Das Entdeckte Geheimniss der Natur im Bau und in der Befructung der Blumen"—the secrets of nature in the forms and fertilisation of flowers discovered—have been reprinted by Engelmann, of Leipzig, in Nos. 48–51 of Ostwald's Klassiker der Exakten Wissenschaften. Every naturalist now knows that Sprengel's theory of insect fertilisation was not a full interpretation of nature's secrets. His careful observations, however, were of prime importance in helping to establish the true theory of cross-fertilisation presented by Darwin some seventy years after the publication of his work. In addition to the above reprint we have received No. 44 of the same series, entitled "Das Ausdehnungsgesetz der Gase." The volume contains a capital collection of papers on the law of gaseous expansion, by Gay-Lussac, Dalton, Dulong and Petit, Rudberg, Gustav Magnus, and Regnault, published from 1802 to 1842.

THERE is a school of philosophers who insist that all investigation into the causes of things is wasted labour, and that science progresses solely through the study of phenomena and their laws. Mr. Lester Ward is not one of these, for in a lecture on the "Status of the Mind Problem," recently delivered before the Anthropological Society of Washington, he showed that the work of Ramón y Cajal, and others, indicated that protoplasm is not merely the physical basis of life, but is the physical basis of mind also. In his words, "the prevailing fashion among scientific men of emphasising the 'mystery of mind' is unnecessary and illogical, since mind is no more a mystery than matter, and all that there is any ground for confessing is that, in consequence of the greater complexity of mental phenomena, due to the higher state of development of the material basis of mind, we possess as yet much less knowledge of them than we do of many of the simpler phenomena of nature."

A SERIES of compounds of sugars with mercaptans, the sulphur alcohols, of a nature similar in many respects to that of the recently isolated glucosides formed by the combination of ordinary alcohols with the sugars, are described by Prof. Emil Fischer in the current *Berichte*. These new substances differ from the glucosides of the alcohols in their constitution, however, for they contain two equivalents of the sulphur alcohol to one equivalent of the sugar; hence they are more nearly allied to the similarly constituted compounds of mercaptans with ordinary aldehydes. The members of the series fully described are the ethyl mercaptals of grape sugar and of galactose, and the amyl mercaptal of the former. In addition to these Prof. Fischer has isolated the ethyl mercaptals of mannose, arabinose, rhamnose, and α-glucoheptose, and has qualitatively proved the generality of the reaction for xylose, maltose, and milk sugar. The compounds appear likely to prove of very great importance, for their formation occurs so readily, that they will serve admirably in many cases as valuable aids in the identification and isolation of either the well-known or newly-discovered sugars. The amyl compound in particular appears likely to be of great service, on account of its slight solubility. They are all substances of considerable stability, and crystallise well. Glucose ethyl mercaptal, $C_6H_{12}O_5(SC_2H_5)_2$, is prepared by mixing ethyl mercaptan with an ice-cold solution of grape sugar in fuming hydrochloric acid. Upon cooling, after the slight rise of temperature which accompanies the reaction, crystals of the new compound separate, and may be advantageously recrystallised from absolute alcohol. The reaction is simply an addition of two molecules of the mercaptan to one of glucose with elimination of a molecule of water.

$$C_6H_{12}O_6 + 2C_2H_5SH = C_6H_{12}O_5(SC_2H_5)_2 + H_2O.$$

Glucose ethyl mercaptal crystallises in colourless needles and plates, which possess a taste very different to that of sugar, being disagreeably bitter. The crystals melt at 127°, and the liquid may be partially distilled at a higher temperature. The substance is only slightly soluble in cold water, and the solution is lævo-rotatory. It behaves as a weak acid, and it is somewhat remarkable that alkalies dissolve the crystals in large quantity, and upon the addition of a dilute acid the compound is precipitated. Indeed the sodium salt, $C_{16}H_{21}S_2O_5Na$, has been isolated in well-defined crystals by treating the compound with sodium dissolved in methyl alcohol. That the substance is very different in its nature from the original glucose is further evidenced by the fact that it does not reduce Fehling's solution. The other members of the series appear to be characterised by similar but graduated properties, the solubility, for instance, diminishing as the homologous series of mercaptans is ascended.

CHLORAURATE of silver, $AgAuCl_4$, an interesting compound of the very soluble and deliquescent chloride of gold with the particularly insoluble chloride of silver, is described by Dr. Hermann, of Aschaffenburg, in the same number of the *Berichte*. This compound has formed the object of previous unsuccessful researches, but its preparation is very simple when the necessary conditions are known. Four parts by weight of metallic gold is dissolved in aqua regia, and the solution evaporated over the water bath, until upon cooling the resulting chlorauric acid, $HAuCl_4$, crystallises. One part by weight of silver dissolved in dilute nitric acid is then added, when silver chloride is precipitated in its usual form. Upon repeated evaporation of the whole with concentrated nitric acid containing a trace of hydrochloric acid the silver chloride changes, becoming coloured bright red, and eventually is completely converted into a mass of crystals of silver chloraurate. The crystals are long prisms terminated by pyramids and dome-faces; they appear to be coloured bright orange-red when singly examined by reflected light, but are pure yellow by transmitted light, and the finely-powdered substance reflects bright yellow light. It is interesting to note that when enclosed in a sealed tube containing perfectly dry air the compound is quite stable and unaffected by bright sunlight, but the moment it is exposed to sunshine in ordinary moist air it commences to bronze, and eventually becomes superficially coated with a dark bronze metallic coating. Dilute hydrochloric acid instantly decomposes it with formation of silver chloride and a solution of chlorauric acid. Ammonia, on the other hand, decomposes it with production of the usual ammoniacal solution of silver chloride and deposition of fulminating gold.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mrs. White; two Cockateels (*Calopsitta novæ-hollandiæ*) from Australia, presented by Mrs. Tidey; a Leadbeater's Cockatoo (*Cacatua leadbeateri*) from Australia, presented by Mr. J. Ward; a White-bellied Eagle (*Haliaetus leucogaster*) from Australia, presented by Mrs. Scales; a Ring-necked Parrakeet (*Palæornis torquatus*) from India, presented by Miss Castle; two Peregrine Falcons (*Falco peregrinus*) British, presented by Mr. Penn C. Sherbrooke; a

Great Eagle Owl (*Bubo maximus*) European, presented by Mr. H. Godman; two Black Apes (*Cynopithecus niger* ♂ ♂) from the Celebes, a Greater Sulphur-crested Cockatoo (*Cacatua galerita*) from Australia, deposited; two Alpine Accentors (*Accentor collaris*) European, purchased; a Coypu (*Myopotamus coypus*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

PHOTOGRAPHIC NEBULOSITIES IN THE MILKY WAY.—In the March number of *Astronomy and Astro-Physics*, and in several recent numbers of *Knowledge*, Prof. E. E. Barnard describes a number of wisps of nebulosity and diffused masses of luminous haze discovered upon photographs taken by him with a portrait lens six inches in aperture and having a focal length of thirty-one inches. A remarkable and large nebulous mass, situated about R.A. 21h. 34m. Decl. + 56° 50′ appeared upon a plate exposed for seven hours. The picture shows a straggling group of bright stars in the centre of the nebula, which is more than two degrees in diameter. The group of stars is visible to the naked eye as a hazy spot, about three degrees north-west of the variable μ Cephei, the brightest star in the group being D.M. + 56° 2617. The star D.M. + 57° 2309 (mag. 6·5) is also shown by the photograph to be surrounded by a rather unsymmetrical dense circular nebulosity. This object was not previously known to be nebulous, though Prof. Barnard says that with the telescope the nebulosity can be seen as a hazy glow about the star. The region of the Milky Way lying north and east of Orion appears to be singularly rich in large diffused nebulosities. Photographs show that ω Orionis and λ Orionis are nebulous, while there is a faint and large diffused glow near the stars ν and ξ Orionis. There was a suspicion of a large nebulosity about α Orionis on one of the plates, but this has not yet been verified. The existence of the other nebulosities, however, has been established either by telescopic observation or new photographs. A photograph obtained at the beginning of last month shows two very singular fan-shaped patches of nebulosity close to γ Cassiopeiæ. These are about 15′ in diameter and point towards the star. They could just be seen by Prof. Barnard with the 12-inch of the Lick Observatory, but he thinks they would never have been detected if the photographic plate had not revealed them. Photographs of the region about 15 Monoceros show that this group of bright stars is mixed up with misty matter having a diameter of about three degrees. The place of 15 Monoceros for 1860 is R.A. 6h. 33m. 16s. Decl. + 10° 1′·3, and the condensation of the remarkable nebula in question is 12′ south preceding the star. Prof. Barnard has now photographed the Milky Way from Scorpio to Orion, discovering many masses of nebulosity on the way. His pictures are not only beautiful views, but valuable records of the structure of the different regions portrayed.

MADRAS OBSERVATORY.—From the report of the Madras Observatory, just published in the Monthly Notices of the Royal Astronomical Society (vol liv. No. 4), it appears that the Secretary of State for India has given his sanction to the proposals made by the Government of India regarding the future of the observatory. The observatory, which has hitherto been under the Madras Government, will, from April 1, be transferred to the Imperial Government. According to the report, a new observatory for solar physics will be erected at Kodarkanal, on the Palani Hills, under the direction of the present officiating Government Astronomer, who will, for the present, also have charge of the existing observatory. The new institution will undertake the work of solar photography now carried on at Dehra Dûn, and will also take up spectroscopic work on the sun, and actinometric researches.

A NEW COMET.—The first comet of this year was discovered by Mr. Denning on Monday evening in R.A. 9h. 55m. Decl. +32° 15′. It was small and faint, and exhibited a short fan-shaped tail. The object was moving towards the east-south-east at the rate of nearly one degree per day.

RECENT INVESTIGATIONS AND IDEAS ON THE FIXATION OF NITROGEN BY PLANTS.

THREE totally different, though convergent, scientific controversies have arisen during the latter half of the present century concerning the *rôle* played in nature by nitrogen, as met with in the air, rain, and soil, free or combined, in connection with the ordinary plants of agriculture and forestry; and, quite apart from their real relations to one another, these three controversies have at times been somewhat confused in their issues.

One of these controversies turned on the question of the transformations of combined nitrogen, as met with in the forms of ammonia, nitrites, and nitrates, and as organic compounds of nitrogen resulting from the decomposition of the remains of living beings—plants and animals—in the soil. The outcome has been the proof that oxidations and de-oxidations of these compounds are intimately bound up with the physiological activities of living organisms, especially bacteria, in the soil; the investigations of Giltáy and Aberson, and Winogradsky's brilliant researches especially, have brought what had long been regarded as purely chemical problems into the domain of biology. "Nitrification" and "de-nitrification," to use the current terms, are phenomena incorporated with those of fermentation, respiration, &c., and therefore involve biological science for their elucidation.

Another of these controversies turned on the question whether the free nitrogen which forms so large a proportion of that huge gaseous ocean, the atmosphere, can be again directly employed by green leaves, and built up as combined nitrogen in plants; or whether, once having been disengaged from organic and other compounds, and passed into the air as gaseous nitrogen, it is for ever lost, except in so far as electric discharges and other energetic physical and chemical processes force this relatively inert element into combinations, which the rain then brings down as inorganic salts, and so help to restore the balance of nitrogenous substances in the soil.

This controversy, a long and involved one, started and for some time continued as a peculiarly chemical question, has passed through various phases and branched out into several subsidiary controversies, if we may so term them.

Thus the alleged "fixation" in the soil, especially investigated by Berthelot and André, became a scientific question apparently on definite lines of its own, and (so far as any such question can be independent) independent of the question whether ordinary green-leafed plants, such as peas, lucerne, wheat, &c. can assimilate the free nitrogen of the atmosphere by processes more or less comparable to those by which they are known to assimilate the carbon they wrench from the carbon-dioxide of that gaseous environment.

The latter question, again, became a divided one, chiefly owing to assertions that green leaves could directly assimilate the ammonia, if not the free nitrogen, of the air, and some time was occupied in arriving at the conclusion that ordinary green plants do not directly assimilate or fix either the gaseous ammonia or the free nitrogen of the atmosphere. This conclusion, in opposition to that arrived at by Ville, was regarded as so thoroughly established by the experiments of Boussingault and of Lawes, Gilbert, and Pugh, that it has been definitely accepted and taught for many years—and rightly so, from the evidence to hand.

The third of the three controversies referred to at the outset, is the more recent one concerned with the question whether certain of the higher green-leafed plants, particularly those known as leguminous plants (such as peas, beans, clovers, vetches, lupins, robinia, &c.), when living as they normally do in symbiotic association with certain microscopic and essentially parasitic fungoid organisms which invade their roots, are differently placed from other green plants as regards the power of "fixing," and assimilating, the free nitrogen of the atmosphere.

The present position of opinions on this last and most remarkable controversy is the subject of this article, so far as it can be done justice to in the short space at disposal.

It is now well known that leguminous plants are normally found to have certain nodosities or swellings on their roots, and that these swellings are caused by the activity of certain minute organisms which, as the writer of this article first proved, invade the roots from outside, after the manner of a parasitic fungus. The controversy as to the exact nature of these organisms—bacteria, according to Prazmowski, Beyerinck, and others, degraded allies of the Ustilagineæ, or some lower fungus, according to my observations, and the confirmatory evidence of Laurent—in no way affects the truth that these organisms do not kill the plants attacked, or even make them diseased, but incite them to more active life for a time. The evidence on

which these organisms (termed "bacteroids") have been taken to be bacteria—their growth in gelatine tubes, staining, and their minute size—is equally in favour of their being lower fungi, and is not sufficiently conclusive. Eventually the nutritious contents of these nodules, with the symbiotic "bacteroids," are absorbed, in whole or in part, by the leguminous plant, and their rich stores of nitrogenous material assimilated by the latter.

The experiments of Hellriegel and Wilfarth, of Lawes and Gilbert, and of others and myself, placed it beyond reasonable doubt that, taking the leguminous plant and its symbiotic organisms together with the pot of soil in which it is grown as a closed system, this system contains more nitrogen at the end of several weeks than can be accounted for by the nitrogen in the soil and the seed at the commencement of the experiment; and this was true in cases where careful precautions were taken to prevent the addition of any nitrogen further than the free nitrogen of the air. The only legitimate conclusion was that somewhere, and somehow, the system fixes free nitrogen from the air.

This matter has been since carried further, however, by Laurent and Schlœsing, who, by growing various plants in an air-tight apparatus under such perfect control that they could analyse the quantity of nitrogen both in the plant and soil, and in the purified air, showed that the gain of nitrogen in the former during the progress of the experiments, is balanced by a corresponding loss in the latter. They further showed that only two kinds of plants could thus "fix" the nitrogen of the air. These are leguminous plants, and certain lower algæ (perhaps mixed with bacteria) or allied forms. This fixation only occurs under certain definite conditions, moreover. The leguminous plants must be infected with the symbiotic "bacteroids," and the algæ must be exposed freely to the air and light in the apparatus: even a thin layer of the sterilised sand employed sufficed to stop the action of the algæ.

Laurent and Schlœsing found no fixation in the case of artichoke, oats, tobacco, mustard, cress, or any other plants experimented with; and their experiments, taken as crowning the edifice of evidence accumulated by them and numerous other observers, have been fairly regarded as proving that leguminous plants, at any rate, and perhaps certain lower algæ, do somehow "fix" the free nitrogen of the atmosphere and assimilate it.

Koch and Kossowitsch have recently claimed to confirm the above results of Laurent and Schlœsing with algæ, and it should be mentioned that Frank had previously stated that such fixation by lower cryptogams occurs. Unfortunately we are as yet uninformed what species of algæ are exactly concerned here, and no one has cultivated them pure and confirmed the results.

It will be noticed that, so far, all that is established is that the infected leguminous plants, and the algæ of sorts, *plus* the known soil (usually sterilised sand to which known additions are made), somewhere and somehow gain in nitrogen at the expense of the free nitrogen of the atmosphere.

Now come the other aspects of the controversy, which is raging chiefly around the question as to exactly where and how this gaseous nitrogen is fixed.

Obviously several possibilities could be suggested.

(1) The gaseous nitrogen could be conceived as directly fixed by the plant which gains in nitrogen—as absorbed by the protoplasm of the living cells exposed to the air—*e.g.* the cells of the leaves of the leguminous plant, or those of the algæ on the surface of the soil. This view is actively maintained by Frank and a few supporters, who go as far as is possible in this direction, and really again raise the old question which originated with De Saussure, and was rightly regarded as refuted by Boussingault and Lawes and Gilbert.

(2) The gaseous nitrogen could be conceived to be fixed in the soil by means of bacteria or lower algæ (we have seen these are left indefinite), and, when it has been converted into nitrogenous compounds of some kind in the soil, eventually absorbed by the roots of the leguminous or other higher green plant in the ordinary course of events. The principal champion of this view is Berthelot, who claims to have proved that certain soil-bacteria, and also the organisms of the leguminous root-nodules, have the power of fixing the free nitrogen of the air, and so enriching the soil in nitrogenous compounds. In this connection, of course, the whole question of nitrification and de-nitrification in the soil will no doubt be involved with the question of the fixation of free nitrogen from the atmosphere.

(3) The fixation of the atmospheric nitrogen could be conceived of as a powerful act of the machinery of the leguminous plant, urged to the necessary expenditure of energy by the stimulating action of the symbiotic organism in its roots. This view, held especially by Hellriegel, Prazmowski, and others, is also shared by Frank, who believes that it is only in their being thus stimulated to greater activity that the leguminosæ differ from many other plants, which, he says, also fix the atmospheric nitrogen directly, but to so much less an extent that the experimental proof of their power to do it is far more difficult.

(4) Another possible view is that the root-organisms act merely as accumulators of nitrogenous material, which has been derived from atmospheric nitrogen fixed and combined in the soil, by physical or chemical processes, or in the open ground by the action of soil-organisms; and the leguminous plant benefits by devouring (if we may employ this word) the bacteroids eventually, and profiting by their stores of nitrogenous material.

Let us now take these four possibilities in order, and examine them a little more in detail.

The first view rests almost entirely on the statements of Frank, of Berlin, who brings forward a number of experiments which in his opinion show that many higher plants, in addition to the leguminosæ, are capable of directly assimilating the free nitrogen of the atmosphere. For instance, Frank gives results showing that oats, buckbeans, spurrey, turnips, mustard, potatoes, and Norway maple are all capable of fixing atmospheric nitrogen.

Most of Frank's experiments were made in the open air, the pots of plants being simply sheltered from rain; but in some cases, he affirms that he got positive increase of nitrogen with mustard-plants under bell-jars, properly shut off from the outer air, and through which purified air was drawn.

Apart from these latter, and in spite of Frank's assertion that the quantities of combined nitrogen in the air are so immeasurably small that they may be neglected, it seems fair to object that, in the present state of science, we cannot trust experiments in the open air to decide such a point; while, with regard to the experiments with mustard, it must not be forgotten that not only the old results of Boussingault and Lawes and Gilbert are entirely and emphatically opposed to them, but the exceedingly careful recent experiments of Schlœsing and Laurent, made with all modern appliances and methods, showed the contrary—no signs of fixation of nitrogen could be obtained in oats, tobacco, cress, mustard, cabbage, spurrey, and potato, the very plants Frank used.

Frank replies that completely normal plants cannot be grown under such closely covered glass vessels as these experimenters use, but he accepts their positive results in all cases. Frank's contention is that the plant must be very vigorous, and near its maturing point, before it has power to energetically seize and "fix" the atmospheric nitrogen; but (without denying that it is possible that the utmost vigour may not be as yet attainable under the conditions necessary for culture in closed glass receptacles of limited capacity) it is impossible to overlook the danger that in experiments in the open air, the time which must necessarily elapse before Frank's critical period of maturity on the part of the plant is reached, is long enough for all sorts of disturbing influences to come in, especially if any kind of "fixation" in the soil, such as Berthelot asserts, really occurs: the root-hairs would take up, and the plant absorb, nitrogenous bodies as fast as they were formed in the soil around them, while there would be ample time for the development of many generations of micro-organisms in the medium.

In view of the tenacity with which the belief in a direct absorption of atmospheric nitrogen is cherished by many foresters and agriculturists, it seems imperative that critical experiments should be persevered in; as matters stand, we cannot accept Frank's position as proved, or even as rendered probable.

The possibility mentioned above as an explanation of the danger of accepting Frank's results would be rendered a certainty if the recent researches of Laurent and Schlœsing, Koch and Kossowitsch, and Berthelot, in part supporting earlier statements by Frank himself, turn out to have been properly interpreted.

Laurent and Schlœsing—and their results are confirmed by Koch and Kossowitsch—declare that sterilised sand, devoid of nitrogenous material, when covered with a growth of certain green and blue-green algæ, probably mixed, however, really does "fix" the atmospheric nitrogen, and gains in nitrogen-

compounds, but only if the algal growth is freely exposed to the atmosphere in the closed chambers employed. These statements confirm earlier, but less definite, experimental results by Frank; and the latter has recently expressly stated that certain fungi—*e.g. Penicillium cladosporioides*—can flourish in a medium to which no nitrogen but that of the atmosphere has access.

Berthelot goes further, and claims to have established that several species of soil-bacteria and fungi, including the fungoid organism of the leguminous tubercles cultivated separately, can "fix" free nitrogen; and if the analyses of the small quantities of materials in his flasks survive the criticism of the chemists, it seems difficult to refuse credence to the views he puts forward; but, as in most of these cases, it is the enormous difficulties of analyses which lie at the root of the matter.

Moreover, different observers differ considerably on this question. Beyerinck, while regarding it as probable that the nodule-organisms "fix" atmospheric nitrogen, admits that he does not prove it; and in Laurent's special investigation into this question, he left it also uncertain; while Immendorf failed to satisfy himself that these organisms can flourish without organic compounds of nitrogen; and Frank insists that they do not thrive at all without organic nitrogenous food-materials. Moreover, it must not be overlooked that other observers, *e.g.* Gautier and Drouin, have given evidence pointing to possible phenomena of "fixation" of nitrogen by compounds of iron and other substances clinging to particles of the sand employed, which may interfere with the accuracy of conclusions drawn from experiments where sterilised soil in the open air is concerned.

When we reflect how very minute these organisms are, and what excessively small quantities of nitrogen they need for their life-purposes, we cannot be surprised at the difficulties met with in these investigations. But, however far from proved we may regard the question of fixation of free nitrogen by soil organisms, it is perfectly clear that here is a most pressing question for further experimental research, and agricultural and forest practice are alike keenly interested in having the question definitely answered.

The third possible view—that the leguminosæ are able to force free nitrogen into combination with other elements, owing to the energetic action of their protoplasmic machinery stimulated by the symbiotic fungoid organism—deserves more consideration than may at first sight appear, especially to those who are not familiarised with the remarkable phenomena of symbiosis generally.

In the first place, the fact that leguminous plants amply provided with the root-nodules *do* "fix" the atmospheric nitrogen, under conditions in which the same plants devoid of the nodules fail to increase their supplies of nitrogen, is far better established than any of the other cases discussed, and must now be accepted as proved by the experiments of Frank, Hellriegel, myself, Lawes and Gilbert, and especially by the recent splendid investigations of Laurent and Schlœsing.

It is true that Frank says the symbiosis is not absolutely necessary for the fixation to proceed, but even he declares that the leguminosæ are stimulated to greater powers of nitrogen-fixation by the nodule-organisms.

A curious and significant confirmation of the symbiosis theory comes from the experiments of Nobbe, Schmid, Hiltner, and Hotter, who find that *Elæagnus* plants, the roots of which develop nodules due to the invasion of a fungus totally different from the one causing the leguminous nodules, also "fix" and assimilate the free nitrogen of the atmosphere, as shown by their growing and flourishing much better and more rapidly than *Elæagnus* plants side by side with them, but not infected with the root organism. It will be interesting to see if further research shows similar results with any of the physiologically similar root-outgrowths, due to very different fungi, met with in *Taxodium*, *Podocarpus*, *Alnus*, *Juncus*, and many other plants, including some vascular Cryptogams.

Now comes the question, in what part of the leguminous plant does the actual "fixation" of the free nitrogen occur? Frank stands practically alone in claiming the leaves to be the organs concerned. Nearly all other observers regard the roots as the region, and the nodules themselves as the actual seat of fixation.

Kossowitsch has even attempted the heroic task of deciding between leaves and roots, by enclosing the former or the latter respectively in air-tight receptacles, shut off from the non-enclosed parts, in which gases devoid of nitrogen were circulated. He could not always keep the apparatus perfectly gas-tight, however, and this and other failures met with in these exceedingly difficult experiments, undoubtedly weakens the force of his conclusions that it is in the roots and not in the leaves that the process occurs, though it does look as if the balance of evidence obtained fairly support his conclusion so far as it goes.

There are facts, however, to be gathered from the microscopic analyses of the root-nodules, as furnished by myself and others, which have been in great part overlooked in the discussions on this subject, and which, although not conclusive, seem to support the view that the seat of fixation may be in the nodules themselves. For instance, the nodules are supplied with a regular system of conducting vascular bundles, communicating with those of the roots; then their cells, during the period of incubation of the symbiotic organism, are abundantly supplied with starch; further, the cells in which the fungoid organism is vigorously flourishing are evidently exceedingly active, as may be deduced from their large size, brilliant nuclei, protoplasm, and sap-vacuole, all of which show signs of intense metabolic activity, lasting for considerable periods. The fact that the sap expressed from these active tissues is alkaline, has been interpreted as in accordance with Lœw's suggestion that the living protoplasm, in presence of an alkali and free nitrogen, can build up ammonium nitrite, or some similar body. Be this as it may, there can be no question as regards the infected nodule-cells being centres where intense physiological activity is going on; and it seems impossible to avoid the conclusion that the vascular supplies from the roots into the nodules bring to these cells water in which various salts, carbo-hydrates, &c. are dissolved, and carry off from them the soluble products of metabolism.

Presumably these products of metabolism include nitrogenous bodies.

In the ordinary course of events, theory teaches that these nitrogenous bodies—*e.g.* amides, preceded by simpler compounds—are built up by the machinery of the ordinary living cell-protoplasm from carbo-hydrates and nitrates, the energy necessary for the metabolism being derived chiefly (if not entirely) by the oxidation of part of the carbo-hydrates supplied.

This constructive metabolic work of the protoplasm is an act which we cannot explain in detail. We can only dimly perceive that it must be due to some remarkable power the protoplasm possesses—and in virtue of which it is an illimitable machine much more economical in its actions than any apparatus we can construct—of so placing the atoms and molecules of the nitrate, carbo-hydrate, water, &c. with which it works, that they are enabled to undergo movements into which we cannot as yet force them in the laboratory.

The whole matter seems to depend on some peculiar mode of presentment of the atoms and molecules concerned; and we can see no further than that this can be done in the living cell, because the protoplasm is a suitable engine for thus bringing the combining elements into the necessary positions in space.

Now, if this is so, there seems no exclusion of the possibility, at any rate, that the cell-machinery may be so stimulated into greater activity that it can even force the notoriously inert nitrogen molecules, properly presented, into combinations with other molecules, resulting in the production of nitrites, amides, or similar bodies in ascending order.

The whole matter no doubt resolves itself into some such question of a properly adapted engine sufficiently supplied with energy. The matter seems capable of explanation, in some degree, if we remember that carbo-hydrates and oxygen are present in abundance; the real difficulty is with the machinery, for we cannot as yet picture the exact construction or working of such an engine, as physiology nevertheless impels us to suppose the cell-protoplasm must be.

It may be remarked, by the way, that the likeness of the living protoplasm to an engine, in the sense implied, may hold good whether the former is an "emulsion," in the sense of the defenders of that hypothesis, or a "structure," in the sense of those who refuse the emulsion hypothesis.

The fourth of the possible views as to the means by which free nitrogen becomes available to the leguminous plant, however, reminds us that, although the evidence points to the stimulated leguminous plant as the best established example of one capable of doing this work, there are other possibilities.

Berthelot's recent insistance that certain soil-bacteria can fix free nitrogen, taken with Frank's, Laurent and Schlœsing's, and

Koch and Kossowitsch's experiments, make it impossible to deny that the above hypothesis as to the powers of the protoplasmic machinery may apply to the cells of some lower organisms, without symbiosis coming into play at all. The remarkable facts brought to light regarding sulphur-bacteria and iron-bacteria by Winogradsky, and the still more unexpected results this observer obtained with nitrifying organisms, show that the machinery of the cell can avail itself of sources of energy undreamt of by earlier observers. If, by the oxidation of sulphur or sulphuretted hydrogen, or of lower iron-compounds, or of ammonia, certain of these organisms can obtain the energy necessary to set going machinery capable of so presenting other molecules of the elements they take up to one another that organic compounds result, it is by no means inconceivable that, at the cost of carbon-compounds which they oxidise powerfully, the necessary energy can be obtained to force even free nitrogen into combinations.

It is equally conceivable that in the case of the leguminosæ, the symbiotic organism is really more of a parasite (it is necessarily a parasite in some degree) than is assumed in the third view, and that, at the expense of the carbo-hydrates so richly furnished to it by the host plant, the fungoid organism alone supplies the machinery for forcing the nitrogen into combination, and that when it has stored up relatively large quantities, owing to its activity in the incubators—the root-nodules—provided for it by its host-plant, and is diminishing in resisting power, the latter at length turns round and absorbs the stores.

The chief objection to this view is that the gains in total nitrogen seem to be greater than would be thus explained, unless the organisms in the soil outside the roots are also fixing free nitrogen.

Such then, put too shortly as regards the numerous experimental facts, are some of the chief ideas agitating the scientific world on this question, a question which, be it emphatically stated, promises to be of more importance to agriculture in the future than any legislation as to prices, &c. that we can conceive; for if it turns out that the acquisition of free nitrogen by the land, or, what amounts to the same thing, the plants growing on it, can be economically promoted, the farmer and forester may have the control of sources of real wealth not yet dreamt of. Unquestionably there is an enormous amount of careful and very difficult experimental work to be done before we arrive at the solution of the various vital questions raised; but the astounding results obtained during the last decade by a few earnest workers promise brilliant results in the future.

H. MARSHALL WARD.

THE HAR DALAM CAVERN AND ITS OSSIFEROUS CONTENTS.

IT is now about half a century since Admiral Spratt first recorded the discovery of the Maltese ossiferous cavern deposits in which, at a later period, Prof. Leith Adams found so remarkable an assemblage of mammalian and other remains.

The fauna which was then brought to light was of a most unique and interesting character, consisting of three species of elephants, one of which *E. falconeri* was, when full grown, no larger than an average size Newfoundland dog; two species of hippopotamus, one *H. minutus*, about the size of a small donkey, several species of gigantic swans, large dormice, land tortoises, cranes, vultures, &c.

These remarkable discoveries in an area so circumscribed attracted much attention in the scientific world, and considerable interest was evinced in them; and this the more so as that Dr. Falconer was at that time engaged in determining certain organic remains which had been found in similar deposits, and under similar conditions, in Sicily. The result of the explorations in the two islands was to demonstrate that Malta had, at no very remote period, been directly in connection with the continental areas on the European side, and indirectly with those of Africa. Brilliant, however, as were the discoveries made by Spratt and Adams, many difficulties of vital interest to the archæologist, the geologist, and the physical geographer were left unsolved when Adams departed from these islands in 1872. Dr. Caruana, a Maltese archæologist, then carried on the work for a short time, but finally abandoned it; and from that time to the arrival of Dr. John Murray, in 1889, nothing further was done. In that and the following year, Dr. Murray undertook a thorough investigation into the marine strata of the islands, and recognising the value of the work that still remained to be done in the Pleistocene beds, he urged the desirability of a careful examination of them being made. Several interesting discoveries of Pleistocene deposits had already been made by Mr. John H. Cooke, in the island of Gozo; and accordingly, at the suggestion of Dr. John Murray, and with the assistance of the Royal Society, Mr. Cooke undertook to carry on the work.

In the spring of 1892 the excavation of a large cavern situate in the Har Dalam Gorge was commenced, the results of which have materially assisted in clearing up many of the more debatable problems which had been left unsolved by previous workers. These results have been embodied, by Mr. Cooke, in a memoir which was communicated to the Royal Society.

The gorge in question is one of many gorges of erosion, which are to be found in the low-lying and denuded areas of Malta and Gozo. It is situated in the eastern part of Malta, and debouches on the broad, extensive bay of Marsa Scirocco. It forms the drainage channel of a catchment basin of considerable area, but owing to the very small annual rainfall of the islands the stream that now courses through it for a few occasional hours in the winter season is insignificant in size, and impotent as an eroding agent.

But it was not always so. The rounded boulders, the waterworn debris, and the curvilinear undercuttings with which the sides of the gorge are scored, as well as the character of the caves in the vicinity and of their deposits, all attest to the former action of torrential volumes of water such as could only have been formed during the existence of climatic conditions of a much more severe and humid nature than those that now endure. The cavern, which has been named after the gorge in which it occurs, is situated 500 yards from the shore on the northern side of the gorge, and consists of a main gallery, 400 feet in length, when it ramifies in various directions, forming smaller tunnels and chambers, which follow the jointings and bedding planes of the rock. One branch fissure is 250 feet in length, 15 feet high, and just wide enough for a man to pass along it, widening out at intervals into dome-shaped rock chambers.

Two of the other galleries are of considerable height, but do not exceed 20 feet in length; and they were filled with débris to within 1 ft. 6 in. to 2 ft. of the roof with a reddish plastic clay, kept moist by percolation from the roof, the sides of all the galleries being encrusted with a stalactitic lining.

The mouth of the main gallery is 26 feet wide and 10 feet high, and has been used during late years as a cattle shelter, the entrance being walled up and provided with a doorway. It widens inwards into a spacious chamber, 60 feet wide and 17 feet high, having a branch on the right hand, which was filled to the roof with alluvial soil and boulders.

The roof of the cavern was formerly covered with stalactites, but most of them have been broken off by the action of the torrents that invaded the cave, and they were afterwards buried in the floor deposits.

These stalactites and their corresponding stalagmitic bosses were observed at three different levels, each being covered by fresh alluvial deposits, indicating the intermittent character of the floods that invaded the cavern and the long periods that elapsed between them.

The deposits met with vary considerably in different parts of the cave. At the furthest extremity they are mainly composed of red loam; in the middle of large boulders, broken stalactites, and old pottery enclosed in clay; towards the entrance of a grey indurated marl with abundant remains of land shells, roots of plants, bones of deer, and boulders.

The cave is everywhere strewn with enormous quantities of waterworn boulders, similar to those met with so abundantly in the valleys and gorges of the islands.

From the differential characters exhibited by the earlier and later layers, it was evident that the deposits belonged to two distinct epochs, each of which was characterised by a special fauna.

In the lower series were found the remains of *Ursus* (*arctos?*), *Elephas mnadrensis*, *Hippopotami pentlandi*, *Canis* (equalling a wolf in size), *Cervus elaphus*, var. *barbarus*, and *Human remains*; while the upper series was found to abound in the remains of man and domestic animals—pig, goat, sheep, *bos*, small land chelonian, and *Cervus elephus*, var. *barbarus*.

The discovery of the carnivoræ was specially significant. As early as 1859 Spratt had observed that many of the bones that

he had exhumed bore traces of having been gnawed; and later on Adams made similar observations.

Notwithstanding, however, the most diligent research extending over a period of twenty years, no further evidences of the presence of carnivoræ were forthcoming. These were the first remains met with.

Equally interesting was the discovery which was made in Trench v. Among the remains which were exhumed Mr. Arthur Smith Woodward has determined the third metacarpal of man. It was found at a depth of 3 ft. 6 in. from the surface, and underlying a layer containing pottery. It is probably of great antiquity, having been extracted from one of the earliest layers in the cavern.

That these deposits are of great antiquity there can be no doubt. The state of mineralisation in which the bones were found was most complete; and when, in addition to this, the height of forty feet above the gorge bed at which the cavern is at present situated be considered, in conjunction with the extremely slow and gradual character of the processes of erosion which were engaged in cutting down the bed of the gorge to its present level—when these, and the other equally important points regarding the great changes in climate that have taken place between this and then be duly weighed, the author thinks that he would be justified in referring the Har Dalam deposits to a considerably remote epoch.

Such then in brief are a few of the evidences bearing on the prehistoric history of the Maltese Islands which these excavations have supplied us with—evidences which have added one more arch to the bridge with which the geologist and the archæologist in the Maltese Islands are endeavouring to span the gulf which at present divides their labours.

GEOGRAPHY IN CAUCASUS.

A RECENT volume of the Memoirs (Zapiski) of the Caucasian Branch of the Russian Geographical Society (vol. xv.) is of more than usual interest. It opens with a paper, by Mr. Konshin, on the old beds of the Amu-daria, accompanied by a map which shows the consecutive decrease of the area of the Caspian sea since the beginning of the Post-Pliocene epoch. It is known that the Russian geologist was first to point out that what had been previously described as old beds of the Amu are not beds at all, but elongated channels occupied once by the salt waters of the Caspian. The writers of antiquity were not wrong in representing the Caspian sea as a basin, elongated from west to east, and in ignoring the existence of Lake Aral as a lake separated from the Caspian. At the beginning of the Post-Pliocene epoch, and perhaps later on as well, the Caspian sent eastward two wide gulfs, one of which reached the longitude of Merv, and covered what is now a depression in the south of the Kara-kum elevated plain; while another gulf, stretching north-eastwards, included Lake Aral and what is now the delta of the Amu, as far as Khiva and Pitnyak. Thus, it was not the Amu which reached the Caspian, but the sea which reached the river by extending much further eastward than it does now. The Chink, which has so often been described as an old bed of the Amu, was the northern coast of the Kara-kum gulf; while the river-like beds of the Sary-kamysh depression were narrow channels through which the waters of Lake Aral occasionally found their way into the Caspian, long time after the two great lakes had been separated from each other. Mr. Konshin's little map very well illustrates the subsequent changes of the form of the Caspian. It may only be added that an exploration of the Ust-urt, and especially of the chain of lakes which crosses it from west to east—connecting, so to say, the Caspian with Lake Aral—is extremely desirable; it seems very probable that another channel of communication between the two great lakes will be discovered in that direction as well. A. V. Pastukhoff's communication about his ascension on the Elbrus and the Khalatsa peak, in July, 1890, is also full of interest, and is accompanied by excellent photographs and a map. On the top of this latter peak, which reaches 11,915 feet, the party was overtaken by a snowstorm, during which they were surrounded by a most beautiful display of electric fires; all their fur coats, their hair, their moustaches, as well as the poles of their tents and all metallic things, were enveloped in luminous discharges, which came to an end only after a discharge of thunder. The thunderstorm was terrible, especially one discharge of globular thunder, which rendered all the party senseless for a time.

Dr. Dinnik's descriptions of his journey in Western Ossetia as well as in Pshavia and Khevsuria, are full of valuable observations, especially as regards glaciers and traces of an extensive previous glaciation of the main chain. And Mr. Filipoff's remarks relative to the present changes of level in the Caspian, show that the level of the sea is continually oscillating in its different parts, and never remains quite horizontal; it depends very much upon the different winds.

Mr. N. Alboff's reports of his botanical explorations in Abhasia and Lazistan are most valuable, the more so as his conclusions relative to the flora of West Caucasus, very different from those arrived at by MM. Krasnoff and Kuznetsoff, are based on most elaborate studies and extensive collections.

Another important paper is contributed to the same volume by K. N. Rossikoff, on the desiccation of lakes on the northern slope of Caucasus. These lakes belong to three different categories. Those on the coasts of both the Caspian sea and the sea of Azov have originated from old lagunæ, or in the deltas of the rivers. They attain but a small depth (3½ fathoms is the maximum depth observed), and many of them are brackish. The lakes of the Steppe-region occupy distinct depressions of the surface, and are fed by little temporary streams and underground water. And, finally, there is a small number of lakes at the footings of the Main Ridge and in the mountain region itself. Now, all the lakes relative to which there are reliable observations made during the years 1881 to 1891, are decidedly in a period of desiccation. Most of the lakes of the Steppe-region have either entirely disappeared, or are living the last years of their existence; they will exist no more in a few years. The lakes scattered at the foot of the mountains are also in decrease; their levels have sunk during the last eight years of the above period by an average of ninety inches. As to the lakes of the mountain region, their desiccation seems chiefly to depend upon the destruction of forests. These facts entirely confirm the widely-spread belief that the climate of Caucasus is becoming more and more dry during the last forty or fifty years.

The volume is concluded with an extensive paper by Dr. Pantyukhoff, full of most valuable anthropological measurements of representatives of the various nationalities and tribes of Caucasus, and accompanied by many engravings.

ISOPERIMETRICAL PROBLEMS.[1]

Dido, B.C. 800 or 900.
Horatius Cocles, B.C. 508.
Pappus, Book v. A.D. 390.
John Bernoulli, A.D. 1700.
Euler, A.D. 1744.
Maupertuis (Least Action), b. 1698, d. 1759.
Lagrange (Calculus of Variations), 1759.
Hamilton (Actional Equations of Dynamics), 1834.
Liouville, 1840 to 1860.

THE first isoperimetrical problem known in history was practically solved by Dido, a clever Phœnician princess, who left her Tyrian home and emigrated to North Africa, with all her property and a large retinue, because her brother Pygmalion murdered her rich uncle and husband Acerbas, and plotted to defraud her of the money which he left. On landing in a bay about the middle of the north coast of Africa she obtained a grant from Hiarbas, the native chief of the district, of as much land as she could enclose with an ox-hide. She cut the ox-hide into an exceedingly long strip, and succeeded in enclosing between it and the sea a very valuable territory[2] on which she built Carthage.

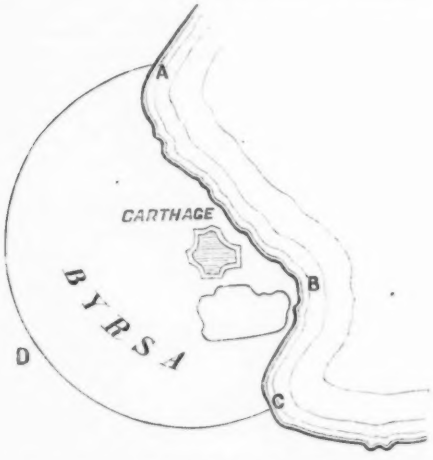
The next isoperimetrical problem on record was three or four hundred years later, when Horatius Cocles, after saving his country by defending the bridge until it was destroyed by the Romans behind him, saved his own life and got back into Rome by swimming the Tiber under the broken bridge, and was rewarded by his grateful countrymen with a grant of as much land as he could plough round in a day.

In Dido's problem the greatest value of land was to be enclosed by a line of given length. If the land is all of equal value the general solution of the problem shows that her line of ox-hide should be laid down in a circle. It shows also that if the sea is to be part of the boundary, starting, let us say, south-

[1] A lecture delivered at the Royal Institution, May 12, 1893, by Lord Kelvin, Pres. R.S.

[2] Called Byrsa, from βύρσα, the hide of a bull. (Smith's "Dictionary of Greek and Roman Biography and Mythology," article "Dido.")

ward from any *given* point A of the coast, the inland bounding line must at its far end cut the coast line perpendicularly. Here, then, to complete our solution, we have a very curious and interesting, but not at all easy, geometrical question to answer:—What must be the radius of a circular arc A D C, of given length, and in what direction must it leave the point A, in order that it may cut a given curve A B C perpendicularly at some unknown point C? I do not believe Dido could have passed an examination on the subject, but no doubt she gave a very good practical solution, and better than she would have found if she had



just mathematics enough to make her fancy the boundary ought to be a circle. No doubt she gave it different curvature in different parts to bring in as much as possible of the more valuable parts of the land offered to her, even though difference of curvature in different parts would cause the total area enclosed to be less than it would be with a circular boundary of the same length.

The Roman reward to Horatius Cocles brings in quite a new idea, now well known in the general subject of isoperimetrics: the greater or less speed attainable according to the nature of the country through which the line travelled over passes. If it had been equally easy to plough the furrow in all parts of the area offered for enclosure, and if the value of the land per acre was equal throughout, Cocles would certainly have ploughed as nearly in a circle as he could, and would only have deviated from a single circular path if he found that he had misjudged its proper curvature. Thus, he might find that he had begun on too large a circle, and, in order to get back to the starting-point and complete the enclosure before nightfall, he must deviate from it on the concave side; or he would deviate from it on the other side if he found that he had begun on too small a circle, and that he had still time to spare for a wider sweep. But, in reality, he must also have considered the character of the ground he had to plough through, which cannot but have been very unequal in different parts, and he would naturally vary the curvature of his path to avoid places where his ploughing must be very slow, and to choose those where it would be most rapid.

He must also have had, as Dido had, to consider the different value of the land in different parts, and thus he had a very complex problem to practically solve. He had to be guided both by the value of the land to be enclosed and the speed at which he could plough according to the path chosen; and he had a very brain-trying task to judge what line he must follow to get the largest value of land enclosed before night.

These two very ancient stories, whether severe critics will call them mythical or allow them to be historic, are nevertheless full of scientific interest. Each of them expresses a perfectly definite case of the great isoperimetrical problem to which the whole of dynamics is reduced by the modern mathematical methods of Euler, Lagrange, Hamilton and Liouville (Liouville's Journal, 1840-1850). In Dido's and Horatius Cocles' problems, we find perfect illustrations of all the fundamental principles and details of the generalised treatment of dynamics which we have learned from these great mathematicians of the eighteenth and nineteenth centuries.

Nine hundred years after the time of Horatius Cocles we find, in the fifth Book of the collected Mathematical and Physical Papers of Pappus of Alexandria, still another idea belonging to isoperimetrics—the economy of valuable material used for building a wall; which, however, is virtually the same as the time per yard of furrow in Cocles' ploughing. In this new case the economist is not a clever princess, nor a patriot soldier, but a humble bee who is praised in the introduction to the book not only for his admirable obedience to the Authorities of his Republic, for the neat and tidy manner in which he collects honey, and for his prudent thoughtfulness in arranging for its storage and preservation for future use, but also for his knowledge of the geometrical truth that a "hexagon can enclose more honey than a square or a triangle with equal quantities of building material in the walls," and for his choosing on this account the hexagonal form for his cells. Pappus, concluding his introduction with the remark that bees only know as much of geometry as is practically useful to them, proceeds to apply what he calls his own superior human intelligence to investigation of useless knowledge, and gives results in his Book V. which consists of fifty-five theorems and fifty-seven propositions on the areas of various plane figures having equal circumferences. In this Book, written originally in Greek, we find (Theorem IX. Proposition X.) the expression "isoperimetrical figures," which is, so far as I know, the first use of the adjective "isoperimetrical" in geometry; and we may, I believe, justly regard Pappus as the originator, for mathematics, of *isoperimetrical problems*, the designation technically given in the nineteenth century[1] to that large province of mathematical and engineering science in which different figures having equal circumferences, or different paths between two given points, or between some two points on two given curves, or on one given curve, are compared in connection with definite questions of greatest efficiency and smallest cost.

In the modern engineering of railways, an isoperimetrical problem of continual recurrence is the laying out of a line between two towns along which a railway may be made at the smallest prime cost. If this were to be done irrespectively of all other considerations, the requisite datum for its solution would be simply the cost per yard of making the railway in any part of the country between the two towns. Practically the solution would be found in the engineers' drawing-office by laying down two or three trial lines to begin with, and calculating the cost of each, and choosing the one of which the cost is least. In practice various other considerations than very slight differences in the cost of construction will decide the ultimate choice of the exact line to be taken; but if the problem were put before a capable engineer to find very exactly the line of minimum total cost, with an absolutely definite statement of the cost per yard in every part of the country, he or his draughtsmen would know perfectly how to find the solution. Having found something near the true line by a few rough trials they would try small deviations from the rough approximation, and calculate differences of cost for different lines differing very little from one another. From their drawings and calculations they would judge by eye which way they must deviate from the best line already found to find one still better. At last they would find two lines for which their calculation shows no difference of cost. Either of these might be chosen; or, according to judgment, a line midway between them, or somewhere between them, or even not between them but near to one of them, might be chosen, as the best approximation to the exact solution of the mathematical problem which they care to take the labour of trying for. But it is clear that if the price per yard of the line were accurately given (however determined or assumed) there would be an absolutely definite solution of the problem, and we can easily understand that the skill available in a good engineer's drawing-office would suffice to find the solution with any degree of accuracy that might be prescribed; the minuter the accuracy to be attained the greater the labour, of course. You must not imagine that I suggest, as a thing of practical engineering, the attainment of minute accuracy in the solution of a problem thus arbitrarily proposed; but it is interesting to know that there is no limit to the accuracy to which this ideal problem may be worked out by the methods which are actually used every day by engineers in their calculations and drawings.

The modern method of the "calculus of variations," brought into the perfect and beautiful analytical form in which we now have it by Lagrange, gives for this particular problem a theorem

[1] Example, Woodhouse's "Isoperimetrical Problems," Cambridge, 1810.

which would be very valuable to the draughtsman if he were required to produce an exceedingly accurate drawing of the required curve. The curvature of the curve at any point is convex towards the side on which the price per unit length of line is less, and is numerically equal to the rate per mile perpendicular to the line at which the Neperian logarithm of the price per unit length of the line varies. This statement would give the radius of curvature in fraction of a mile. If we wish to have it in yards we must take the rate per yard at which the Neperian logarithm of the price per unit length of the line varies. I commend the Neperian logarithm of price in pounds, shillings and pence to our Honorary Secretary, to whom no doubt it will present a perfectly clear idea; but less powerful men would prefer to reckon the price in pence, or in pounds and decimals of a pound. In every possible case of its subject the "calculus of variations" gives a theorem of curvature less simple in all other cases than in that very simple case of the railway line of minimum first cost, but always interpretable and intelligible according to the same principles.

Thus in Dido's problem we find by the calculus of variations that the curvature of the enclosing line varies in simple proportion to the value of the land at the places through which it passes; and the curvature at any one place is determined by the condition that the whole length of the ox-hide just completes the enclosure.

The problem of Horatius Cocles combines the railway problem with that of Dido. In it the curvature of the boundary is the sum of two parts; one, as in the railway, equal to the rate of variation perpendicular to the line, of the Neperian logarithm of the cost in time per yard of the furrow (instead of cost in money per yard of the railway); the other varying proportionally to the value of the land as in Dido's problem, but now divided by the cost per yard of the line, which is constant in Dido's case. The first of these parts, added to the ratio of the money-value per square yard of the land to the money-cost per lineal yard of the boundary (a wall suppose), is the curvature of the boundary when the problem is simply to make the most you can of a grant of as much land as you please to take provided you build a proper and sufficient stone wall round it at your own expense. This problem, unless wall-building is so costly that no part of the offered land will pay for the wall round it, has clearly a determinate finite solution if the offered land is an oasis surrounded by valueless desert. It has also a determinate finite solution even though the land be nowhere valueless, if the wall is sufficiently more and more expensive at greater and greater distances from some place where there are quarries, or habitations for the builders.

The simplified case of this problem, in which all equal areas of the land are equally valuable, is identical with the old well-known Cambridge dynamical plane problem of finding the motion of a particle relatively to a line of reference revolving uniformly in a plane: to which belongs that considerable part of the "Lunar Theory" in which any possible motion of the moon is calculated on the supposition that the centre of gravity of the earth and moon moves uniformly in a circle round the sun, and that the motions of the earth and moon are exactly in this plane. The rule for curvature which I have given you expresses in words the essence of the calculation, and suggests a graphic method for finding solutions by which not uninteresting approximations[1] to the cusped and looped orbits of G. F. Hill[2] and Poincaré[3] can be obtained without disproportionately great labour.

In the dynamical problem, the angular velocity of the revolving line of reference is numerically equal to half the value of the land per square yard; and the relative velocity of the moving particle is numerically equal to the cost of the wall per lineal yard in the land question.

But now as to the proper theorem of curvature for each case; both Dido and Horatius Cocles no doubt felt it instinctively and were guided by it, though they could not put it into words, still less prove it by the "calculus of variations." It was useless knowledge to the bees, and, therefore, they did not know it; because they had only to do with straight lines. But as you are not bees I advise you all, even though you have no interest in acquiring as much property as you can enclose by a wall of given length, to try Dido's problem for yourselves, simplifying it, however, by doing away with the rugged coast line for part of your boundary, and completing the enclosure by the wall itself. Take forty inches of thin soft black thread with its ends knotted together and let it represent the wall; lay it down on a large sheet of white paper and try to enclose the greatest area with it you can. You will feel that you must stretch it in a circle to do this, and then, perhaps, you will like to read Pappus (Liber V. Theorema II. Propositio II.) to find mathematical demonstration that you have judged rightly for the case of all equal areas of the enclosed land equally valuable. Next try a case in which the land is of different value in different parts. Take a square foot of white paper and divide it into 144 square inches to represent square miles, your forty inches of endless thread representing a forty miles wall to enclose the area you are to acquire. Write on each square the value of that particular square mile of land, and place your endless thread upon the paper, stretched round a large number of smooth pins stuck through the paper into a drawing-board below it, so as to enclose as much value as you can, judging first roughly by eye and then correcting according to the sum of the values of complete squares and proportional values of parts of squares enclosed by it. In a very short time you will find with practical accuracy the proper shape of the wall to enclose the greatest value of the land that can be enclosed by forty miles of wall. When you have done this you will understand exactly the subject of the calculus of variations, and those of you who are mathematical students may be inclined to read Lagrange, Woodhouse, and other modern writers on the subject. The problem of Horatius Cocles, when not only the different values of the land in different places but also the different speed of the plough according to the nature of the ground through which the furrow is cut are taken into consideration, though more complex and difficult, is still quite practicable by the ordinary graphic method of trial and error. The analytical method of the calculus of variations, of which I have told you the result, gives simply the proper curvature for the furrow in any particular direction through any particular place. It gives this and it cannot give anything but this, for any plane isoperimetrical problem whatever, or for any isoperimetrical problem on a given curved surface of any kind.

Beautiful, simple, and clear as isoperimetrics is in geometry, its greatest interest, to my mind, is in its dynamical applications. The great theorem of least action, somewhat mystically and vaguely propounded by Maupertuis, was magnificently developed by Lagrange and Hamilton, and by them demonstrated to be not only true throughout the whole material world, but also a sufficient foundation for the whole of dynamical science.

It would require nearly another hour if I were to explain to you fully this grand generalisation for any number of bodies moving freely, such as the planets and satellites of the solar system, or any number of bodies connected by cords, links, or mutual pressures between hard surfaces, as in a spinning-wheel, or lathe and treadle, or a steam engine, or a crane, or a machine of any kind; but even if it were convenient to you to remain here an hour longer, I fear that two hours of pure mathematics and dynamics might be too fatiguing. I must, therefore, perforce limit myself to the two-dimensional, but otherwise wholly comprehensive, problems of Dido and Horatius Cocles. Going back to the simpler included case of the railway of minimum cost between two towns, the dynamical analogue is this:—For price per unit length of the line substitute the velocity of a point moving in a plane under the influence of a given conservative system of forces, that is to say, such a system that when material particles not mutually influencing one another are projected from one and the same point in different directions, but with equal velocities, the subsequent velocity of each is calculable from its position at any instant, and all have equal velocities in travelling through the same place whatever may be their directions. The theorem of curvature, of which I told you in connection with the railway engineering problem, is now simply the well-known elementary law of relation between curvature and centrifugal force of the motion of a particle.

The motion of a particle in a plane is, as Liouville has proved, a case to which every possible problem of dynamics involving just two freedoms to move can be reduced. But to bring you to see clearly its relation to isoperimetrics, I must tell you of another admirable theorem of Liouville's, reducing to a still simpler case the most general dynamics of two-freedoms motion. Though not all mathematical experts, I am sure you can all per-

[1] Kelvin, "On Graphic Solution of Dynamical Problems." *Phil. Mag.* 1892 (2nd half-year).
[2] Hill, "Researches in the Lunar Theory," Part 3. "National Academy of Sciences," 1887.
[3] "Méthodes Nouvelles de la Mécanique Céleste," p. 109 (1892).

fectly understand the simplicity of the problem of drawing the shortest line on any given convex surface, such as the surface of this block of wood (shaped to illustrate Newton's dynamical theory of the elliptic motion of a planet round the sun) which you see on the table before you. I solve the problem practically by stretching a thin cord between the two points, and pressing it a little this way or that way with my fingers till I see and feel that it lies along the shortest distance between them. And now, when I tell you that Liouville has reduced to this splendidly simple problem of drawing a shortest line (geodetic line it is called) on any given curved surface every conceivable problem of dynamics involving only two freedoms to move, I am sure you will understand sufficiently to admire the great beauty of this theorem.

The doctrine of isoperimetrical problems in its relation to dynamics is very valuable in helping to theoretical investigation of an exceedingly important subject for astronomy and physics—the stability of motion, regarding which, however, I can only this evening venture to show you some experimental illustrations.

The lecture was concluded with experiments illustrating—

(1) Rigid bodies (teetotums, boys' tops, ovals, oblates, &c.) placed on a horizontal plane, and caused to spin round on a vertical axis, and found to be thus rendered stable or unstable according as the equilibrium without spinning is unstable or stable.

(2) The stability or instability of a simple pendulum whose point of support is caused to vibrate up and down in a vertical line, investigated mathematically by Lord Rayleigh.

(3) The crispations of a liquid supported on a vibrating plate, investigated experimentally by Faraday; and the instability of a liquid in a glass jar, vibrating up and down in a vertical line, demonstrated mathematically by Lord Rayleigh.

(4) The instability of water in a prolate hollow vessel, and its stability in an oblate hollow vessel, each caused to rotate rapidly round its axis of figure,[1] which were announced to Section A of the British Association at its Glasgow meeting in 1876 as results of an investigation not then published, and which has not been published up to the present time.

GEOLOGICAL SURVEY OF THE UNITED KINGDOM.[2]

II.

SCOTLAND.

Lewisian Gneiss.—The most ancient rocks in the British Islands, forming what is known as the Lewisian Gneiss, have now been mapped continuously throughout the whole of their extent on the mainland, from Cape Wrath to the Kyles of Skye. They have been found to occur there in two distinct conditions. Along the western borders of Sutherland and Ross they form an irregular platform on which all later formations rest. The detailed work of the survey has brought to light the fact that this platform had an exceedingly uneven surface before the very oldest of the sedimentary formations were laid down upon it. Mountains of gneiss from 2000 to 3000 feet high, with wide and deep intervening valleys, already existed before the period of the Torridon Sandstone, and were submerged beneath the waters in which that Sandstone was accumulated. But to the east of this primeval topography, owing to the gigantic dislocations which have now been traced for upwards of 100 miles from the northern shores of Sutherland into Skye, large slices of the deeply buried gneiss have been torn off and have been driven westward upon fractured and crushed rocks of much later date. There are thus areas of gneiss which have been moved and have undergone much consequent internal rearrangement, while to the west of these the old platform, still in great part covered with the younger formations, has been left unaffected and reveals the condition of the oldest rocks at the time when the earliest of these over-lying formations was deposited upon them.

The mapping of this region has shown the Lewisian Gneiss to consist of what were probably masses of various deep-seated igneous rocks, which, partly by segregation and intrusion, and partly by subsequent intense mechanical deformation, have in large measure acquired a gneissic structure. An order of sequence has been made out among the more marked types of erupted material, and it has been further ascertained that the structures superinduced by crushing have taken place at successive periods of great disturbance.

Some of the most important observations in the area of the ancient gneiss are those made in the Loch Maree district. Mr. Clough has found there a group of rocks quite unlike the usual types of the Lewisian series. They consist chiefly of fine mica-schist, quartz-schist, graphite-schist, and limestone, and may be altered sedimentary rocks. If such should prove to be their origin they will possess a special interest as being by far the most ancient vestiges of detrital deposits yet detected in this country. The relation of these rocks to the normal types of gneiss around them have not been very satisfactorily determined.

In the course of the examination of the old gneiss where it lies undisturbed below the unmoved Torridon Sandstone, the officers of the Survey have ascertained that it had undergone successive disruptions and much mechanical deformation before the deposition of that Sandstone, that in short it had already acquired all its present structure and had been irregularly and deeply laid bare by denudation. We are still unable to say how far the earliest foliated arrangement of the gneiss may be due to movements such as those of flow-structure within a plutonic magma, in which the component minerals have segregated out. But there can be no doubt that after any such early structure had been established other structures were superinduced upon the gneiss by subterranean movements. Evidence of these disruptions and of their effects has now been accumulated over the whole area of the mainland.

Torridonian.—The striking mass of chocolate-coloured sandstones, which enters so prominently into the scenery of the west of Sutherland and Ross-shire, has now been mapped throughout its extent on the mainland, with the exception of a small area in the west of the latter county which remains to be completed. Like the far more ancient gneiss on which these strata rest with so marked an unconformability, they are met with in two distinct conditions. To the westward, where they have escaped from the great dislocations already referred to, they lie in almost their original undisturbed positions, insomuch that one can hardly at first realise that their relative antiquity can be so great as it demonstrably is. They resemble portions of the Old Red Sandstone with which at first they were identified, and this resemblance extends even into the practical uses that may be made of them. Along many parts of the West of Sutherland and Ross-shire the thick bedded chocolate-coloured freestones would furnish an excellent building stone in practically unlimited quantities.

An important group of shales has been found to occupy a prominent place towards the base of the Torridon Sandstone in Western Ross-shire. This group has now been followed to the sea-coast, and has been found by Mr. Clough to attain a still larger development in the southern part of the island of Skye. They there contain thin bands of impure limestone, and one of their members of much interest, forming only a thin bed, consists largely of grains of magnetite and zircon. A diligent search for fossils has recently been made by Mr. A. Macconochie in this lower shaly group of the Torridon Sandstone, but hitherto with scarcely any success, certain doubtful track-like markings being the only indications of possible organic remains which have been met with.

In mapping the Applecross district, where the Torridon Sandstone rises into an imposing group of mountains, Mr. Horne has encountered some singular volcanic orifices on a sandstone plateau about 1000 feet above the sea. Two small "necks" which rise there through the Torridon rocks, are filled with blocks of the sandstone mingled with occasional bombs of basalt, the whole being set in a dark green and grey paste of similar materials. The fragments of sandstone have been subjected to considerable alteration, for they have a glazed aspect, while their quartz-grains have acquired a milky opalescent or blue tint. There is no indication of the age of these two volcanic vents, but they may with some probability be assigned to the widespread Tertiary series which has left such prominent memorials in the opposite island of Skye.

During the past year in the district between Loch Kishorn

[1] NATURE, 1877, vol. xv. p. 297, "On the Precessional Motion of a Liquid."

[2] Annual Report of the Geological Survey for the year ending December, 31, 1892. By Sir Archibald Geikie, F.R.S., Director General. From the Report of the Science and Art Department for 1893. (Some of those portions of the Report which describe the scientific results of the Survey operations during the last few years are reprinted here). (Continued from page 497.)

and the head of Loch Carron some tracts of Torridon Sandstone have been mapped, where the effects of the great displacements upon the internal structure of the sandstone are well displayed. In that region, by the effect of these stupendous movements, a wide area of Torridon Sandstone and old gneiss has been inverted and pushed bodily westwards so as now to lie upon the Cambrian formations. This inversion is seen on a great scale in the district of Loch Carron, where the Torridon Sandstone, pushed over the quartzites and limestones, dips eastward for several miles until its base passes under the overturned Lewisian gneiss. The actual inverted unconformable junction of the gneiss and sandstone can still be traced in various places, though elsewhere it has been effaced by intense deformation. And not only may the inverted unconformability be recognised, but it can be shown that an overlap of the older parts of the Torridon Sandstone takes place against the uneven surface of the overlying gneiss. Messrs. Peach and Horne, who have mapped this remarkable structure, find that the sandstones have been crushed and have become partially schistose, with a development of mica and other minerals along the planes of movement; also that pegmatitic veins of quartz and felspar have been formed by segregation in rents of the strata.

The same intense subterranean movements have profoundly affected the structure of the overlying masses of old gneiss. As these rocks are followed eastwards for several miles they appear more and more sheared, until at last they are succeeded by siliceous granulitic flagstones, such as have been named by the surveyors "Moine-schists." On the south side of Loch Carron, Mr. Peach has recently obtained evidence which, if confirmed by further research, will have an important bearing on the interpretation of these schists, which have hitherto presented a very difficult problem. He finds that from the nature of the schists and their mode of occurrence in that locality, they appear to be altered Torridon Sandstone, which has been caught and enclosed within a great synclinal fold by the mass of old gneiss as it was driven westward. They consist of material similar to that of the undoubted Torridon Sandstone, where it has been affected by the greater movements, and they show in many places that they have been originally pebbly felspathic grits. To the eastward of this zone of probably clastic material other huge masses of the Lewisian gneiss have been pushed up and more or less deformed.

Eastern or Younger Gneiss.—While the chief part of the working season in the north-west Highlands has been devoted to the prosecution of the critical work in the districts just referred to, some progress has also been made in the mapping of the area of the eastern or younger schists (Moine-schists), which, brought forward by the higher thrust-planes, spread over so large an area of Sutherland and Ross. I have referred above to the extreme difficulty of ascertaining what has been the origin of these schists, and to the suggestive observations of Mr. Peach which may eventually lead to the recognition of these rocks as altered sediments. When the officers of the survey some years ago made a few preliminary traverses across the north of Sutherland, before beginning to map that region in detail, they were disposed to believe that certain belts of coarse, banded, gneisses which appear on the coast, were portions of the old gneiss that had escaped the crushing which produced the peculiar granulitic structure of the so-called Moine-schists. Closer examination and detailed mapping of these rocks have led Mr. Horne to modify this view. He regards it as certain that altered sediments form an integral portion of the granulitic schists and gneiss of that district. But he also finds that these schists and gneisses are traversed by abundant belts and veins of foliated and unfoliated granite, showing no cataclastic structure. From these larger portions of granitic material countless minute folia of the same substance have proceeded along the foliation planes of the schists. Hence three distinct types of gneiss have been produced: (1) granitoid gneiss or gneissose granite; (2) an intermediate type consisting of alternations of granulitic and granitic materials; (3) well-banded biotite-gneiss. If these Kirktomy gneisses really belonged to the Lewisian system, it would follow that the granitic types thus developed must be later than the granulitic schists and gneisses. If, on the other hand, as is most probable, they are of post-Cambrian age, then we must admit that in rocks of this type petrographical characters cannot be regarded as furnishing by themselves a reliable chronological index.

Schists of Central and Southern Highlands.—In the Central and Southern Highlands, accumulating evidence, both in the field and, as already stated, from microscopical research, goes to show that the main mass of the rocks composing that region are a thick and varied series of sedimentary deposits which, together with their associated igneous materials, have undergone extensive metamorphism. The degree of alteration sometimes reaches a point beyond which the original clastic structures are no longer traceable. But even where this is the case with some members of the series, others are found associated with them which can be recognised, and which indicate the persistence of the several stratigraphical groups. An area where there has been hardly any metamorphism has recently been mapped by Mr. J. E. Hill in the district of Loch Awe. The rocks in that tract consist of grits, phyllites and limestones, which in their unaltered condition resemble ordinary Palæozoic sedimentary strata. These have been traced by Mr. Hill continuously into the crystalline schists of the central Highlands.

Much attention has recently been given to the eruptive rocks associated with the schists of the central and southern Highlands. Some of these are dark basic sills, which were injected before the plication and metamorphism of the surrounding rocks, others are later granitic intrusions, probably of different epochs of eruption. That a gradation from basic to acid composition within the same eruptive mass may sometimes be detected, indicating probably the order of consolidation of the component materials of an igneous protrusion, has been well shown by recent work of Messrs. Dakyns and Teall. Mr. Barrow's work in Forfarshire has brought to light the existence of a vast number of comparatively small bosses, veins, or lenticles of a granite, with both white and black mica, and usually showing a more or less distinctly foliated structure. He has also found numerous intrusions of a biotite gneiss. Both these rocks are accompanied by an alteration of the surrounding schists.

Jurassic.—In pursuance of the plan of field-work sketched in previous reports, Mr. H. B. Woodward was stationed in the Isle of Raasay, for the purpose of mapping the various members of the Jurassic series there exposed. He had nearly completed this survey when the short season came to an end, having traced the limits of the Great and Inferior Oolite, the Upper, Middle, and Lower Lias, and the Red Rocks underlying the Lias which are probably of Triassic age. In the course of his work he discovered a hitherto unsuspected bed of Oolitic ironstone in the upper part of the Middle Lias. A thickness of 4 feet 6 inches was seen by him, but the bed may possibly be a little thicker. In geological position this bed corresponds with the well known Cleveland iron-ore and other seams. An analysis, made by Mr. A. Dick, junr., under the superintendence of his father Mr. Allan Dick, who made in 1856 one of the earlier analyses of the Cleveland ore, showed the Raasay stone to contain a little more than 30 per cent. of metallic iron, the proportion in the Cleveland ore ranging from 30 to a little above 33 per cent.

Glacial Deposits.—In Scotland the mapping of the superficial deposits has gone on simultaneously with that of the solid rocks underneath, and in some parts of the country, where these deposits are especially complicated, the progress of the surveying is necessarily somewhat retarded. In the north-west Highlands some singular evidence has been obtained as to the thickness and flow of the great ice-sheet, at what seems to have been the time of maximum glaciation. Not only are the sides of the mountains well ice-worn, but there is evidence that the fragments of the characteristic Moine-schists of the interior of Sutherland and Ross have been carried up westward across the great ridges, thus proving that the axis of movement of the ice did not coincide with the present watershed of the country.

Some interesting relics of the later or valley glaciers have been mapped at Loch Torridon. Mr. Hinxman has traced the moraines down to the latest raised beaches of the west coast, Mr. Peach finds evidence that in the north of Sutherland glaciers continued to shed their moraines in the sea at the time of the formation of the 50-feet Raised Beach. Some of the high-level terraces of the River Naver in that district appear to have been formed between the edge of the ice and the side of the valley at a time when a glacier passed down the bed of the valley. Successive terraces, formed in this way as the glacier shrank backwards, may never have reached across the valley, though similar shelves of gravel may now occur on either side.

IRELAND.

The most important recent work of the staff of the survey of Ireland has been a re-examination of certain portions of the country with the view of determining how far the gneisses and schists represented on the maps could be correlated with those

of Great Britain, and in particular whether any of them could be separated from the rest and compared with the Lewisian or Anglesea gneisses of undoubtedly pre-Cambrian age. When the mapping of these rocks by the Survey was begun many years ago, no attempt had been made by geologists to distinguish the various pre-Cambrian groups of rock now known to exist in Britain, and when the survey of the country was completed by the mapping of Donegal, all that could be definitely stated about the schists of that region was that they were in the main metamorphosed sedimentary deposits, like those of the central and south-western Highlands of Scotland, of which they were obviously a prolongation. No certain trace could there be found of any nucleus of still more ancient rocks upon which these altered sediments had originally been deposited. It was recognised, however, that in other parts of Ireland rocks had been met with in the course of the survey which presented some resemblance to so-called "Archæan" masses, but of which the stratigraphical relations and petrographical characters had not been worked out. It was thus possible that isolated areas of pre-Cambrian rocks might be detected if diligently sought for, and that in this way traces might be recovered of the earliest topography of the region.

Some progress has now been made in this interesting search, and successful results have been obtained, whereby the mapping of the older formations has been materially improved. In the west of Tyrone and the adjacent borders of Donegal a group of rocks was found to present many of the typical characters of the Lewisian gneiss of the north-west of Scotland. Mr. McHenry, who first suggested the true nature of these rocks, was instructed to map them out in conjunction with Mr. Kilroe. They were found to occupy a clearly defined area and to be easily separable from the schists and quartzites of Donegal which are classed with the metamorphosed rocks of the south-western Highlands of Scotland. Unfortunately no distinct line of contact between the two groups of rock was traceable, though there could be little doubt that they must be separated by a great unconformability, and that the older gneiss had already acquired much of its present character before the deposition and metamorphism of the younger schistose series.

Probably the most important tract yet examined is that of the long ridge which runs from Sligo to Castlebar, and of which the Slieve Gamph or Ox Mountains form a conspicuous portion. Here Mr. McHenry has found that at the base of the younger series coarse conglomerates occur, made out of the gneiss, and lying apparently in violent unconformability upon the older rock. If this observation is confirmed, it will establish an important point, not only in Irish but in British geology. It will show that the metamorphosed sedimentary rocks which form now the schists that build up the central and north-western Highlands of Scotland and the north-west of Ireland lie upon the uneven surface of an ancient gneiss, which presents the characters of the Lewisian gneiss of Sutherland and Ross-shire.

SCIENTIFIC SERIALS.

American Journal of Science, March.—Continuity of the glacial epoch, by G. F. Wright. In opposition to the author's view that the erosion of the rocky gorge of the Ohio river and its tributaries was preglacial, Prof. Chamberlin has maintained that the most important part of this rock erosion was interglacial. The author summarises the leading facts concerning the American glacial epoch by supposing that the earlier portions of the tertiary period were characterised by low altitude of land and warm temperature up to near the pole. A period of slow continental elevation of the regions which are now covered by glacial drift was in progress late in the pliocene epoch. During this stage the fiords of northern Europe and America and the extensive rocky gorges, like those of the upper Ohio and its tributaries, were eroded. Owing to this elevation glacial conditions characterised all the higher latitudes of North America and Western Europe. The glaciated area then began to sink until the land was, north of the great lakes at any rate, several hundred feet lower than it is now. The channels of the Allegheny, the Susquehanna, and the Delaware rivers were silted up by glacial débris, but were re-excavated by torrents of clear water during the re-elevation of the continent consequent upon the melting of some thousands of feet of ice. There were doubtless many oscillations of the ice-front both during the general advance and the general retreat of the ice-sheet, but there does not seem to be any evidence of oscillations of the front sufficient to break the proper continuity of the period.—Deformation of the Lundy Beach and birth of Lake Erie, by J. W. Spencer. The inferred rate of terrestrial deformation in the Niagara district being 1·25 feet a century, it appears that before Niagara Falls can have receded past the Devonian ridge near Buffalo, the drainage of the upper lakes will have been turned into the Mississippi valley, which may require 7000 or 8000 years.—Six and seven-day weather periods, by H. Helm Clayton. The observation of barometric minima reveals many instances of six and seven-day periodicities lasting several weeks, and sufficiently striking to be easily recognised. In the case of successive individual storms, it was found that during an interval of about twenty-seven days, corresponding with a solar rotation, the storm tracts were found in groups, in each of which the cyclones all followed the same general direction, and were separated from each other by intervals of six or seven days, or in some cases by half these intervals.

Symons's Monthly Meteorological Magazine, March.—A wet February in Edinburgh, by the Editor. In different parts of Edinburgh observations of rainfall have been made for 116 years, the wettest previous February being 5·21 inches, in 1848, while this year the fall amounted to 7·62 inches at one station, or more than four and a half times the average.—Mild winter weather, by A. B. M. The writer points out that for a long time past (since the beginning of the century at least) we have had a conspicuously mild first quarter of the year every twelve or thirteen years. The average mean temperature for London for the first quarter for 130 years, according to Buchan, is 39°·8; the first quarter quoted is 1809, 42°·1, and the last 1884, 43°·6. According to this we might expect the first quarter of 1896 or 1897 to have a high mean temperature. With the exception of the first year, 1809, the mild quarters have been followed by fine, hot summers.

L'Anthropologie, tome iv. No. 6, November–December, 1893.—In 1891 Dr. Topinard was requested by the *New York Herald* to give his opinion as to the qualities that should be possessed by (1) *the perfect man*, and by (2) *the coming man*. He replied to the first question in a brief note which has since been embodied, with about 150 others of a similar character, in a work entitled "Ideals of Life," by Dr. Wallace Wood, of New York. Dr. Topinard now discusses the subject at greater length in an article on "Certain inferences and applications of Anthropology." From a natural history point of view, *the perfect man* is he who, with the highest sense of his own personality, can best adapt himself to circumstances, and possesses personal advantages which assure him, in the struggle for existence, pre-eminence over his fellows, over other species, and over the agencies and powers of nature. It is he who has the soundest mind in the healthiest body, and commands, especially, the greatest power of estimating the importance of his actions, and of making them conduce to the utmost to the satisfaction of his necessities, his interest, and his pleasure. From the social point of view, *the perfect man* is he who is the best adapted to that state; who possesses in the highest degree sentiments of fellowship, of justice, of altruism, of the distinction between good and evil, of duty, &c. which have been bequeathed to him by his ancestors, and which form the essential basis of our social organisation; who regards these principles as articles of faith, and makes them the invariable rule of his own conduct. From the psychological point of view, *the perfect man* is he whose brain is the healthiest, the most philosophic, the most capacious, and the most active; who comprehends and retains the most, and who can, with the best effect, draw upon his storehouse of knowledge at a moment's notice.—M. Ch. Féré contributes a short note on the relation of the length of the trunk to the height, in which he shows that the relative proportion becomes gradually less as the stature increases.—M. Salomon Reinach continues his criticism of the Eastern Mirage, and discusses, in this number, the influence exercised by Egypt and Assyria on the civilisation of Eastern Europe.—M. G. De Lapouge describes sixty-two crania taken from a modern cemetery at Karlsruhe. These crania had been previously measured by Dr. Wilser, directly after they had been cleaned, and very shortly after their removal from the vault, and it was agreed that these two anthropologists should publish the results of their observations independently, so that the modifications produced by drying might be studied, and that an estimate might be formed of the different results

given by the craniometric methods of Broca and Jhering. M. Lapouge measured the skulls exactly one year after Dr. Wilser, and during the whole of that time they had been thoroughly dried under the sunny roof of his laboratory at Montpelier. He also made a double series of measurements of the length and breadth of the skulls, first, by Broca's method, with a pair of calipers, and secondly, with Ammon's sliding compass, and after the method of Jhering, in precisely the same manner as Dr. Wilser's observations had been made. The results obtained are exceedingly interesting, and show that, in competent hands, it is a matter of perfect indifference which instrument is used, and that although, as one would naturally expect, the cephalic index is slightly greater when Jhering's method is employed, yet the difference is so small as to be almost insignificant. By Jhering's method the mean index of the series is 82·54, while Broca's index is 81·87. Both the length and breadth of the skull appear to be somewhat increased by drying, and the value of the cephalic index is a little raised, that obtained by Dr. Wilser from the fresh skulls being 81·84, while M. Lapouge's measurements of the dried skulls gave an index of 82·54. It will be observed that the difference is almost exactly the same as the excess of Jhering's index over Broca's. The flattening of skulls under the influence of desiccation is a phenomenon well known to all anthropologists, and in the case of these Karlsruhe skulls the mean diminution of height was more than a centimetre, so that, although the hygrometric conditions under which skulls are measured do not seem to affect the cephalic index of a series to an appreciable degree, the vertical and transverse indices of damp and dry crania are not comparable with one another.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, March 9.—Prof. A. W. Rücker, F.R.S., President, in the chair.—Prof. O. Henrici, F.R.S., made a communication on mathematical calculating machines, especially a new harmonic analyser. After mentioning the general principles on which such machines are based, the author showed a new arithmometer devised by Prof. Selling, in which the jerky motions of the numeral wheels common in such instruments are eliminated, and the operations simplified. Another arithmometer of very compact design, named the "Brunsviga," had been placed on the table by Prof. Boys. The simple and ingenious "hatchet" integrator was then shown. It resembles a small hatchet with a tracing-point projecting at right angles to, and at the end of, the handle. Moving the point from near the centre of mass of any closed curve, round the curve once and back to the starting-point, the distance between the initial and final positions of the hatchet-head is a measure of the area of the curve. The instrument has been found very useful for indicator diagrams. A Hine and Robertson's planimeter (lent by Prof. Perry), an Amsler planimeter combined with a pentograph for measuring small areas, an Amsler integrator to give areas and first moments, and a beautiful sphere and cylinder rolling-integrator of great accuracy, by Coradi of Zürich, were shown, as well as an ingenious integraph devised by Abdank Abakonowitcz. Passing on to harmonic analysers, Prof. Henrici explained the object of such instruments, viz. to determine the coefficients in Fourier's expansion for any periodic curve,

$$y = A_0 + A_1 \cos\theta + A_2 \cos 2\theta + \ldots + B_1 \sin\theta + B_2 \sin 2\theta + \ldots$$

and briefly described Lord Kelvin's instrument now in use at the Meteorological Office. This machine gives the first term and three pairs of coefficients A and B, but is large and expensive. The author had endeavoured to devise a simple and more portable instrument, and now described the various stages in the evolution of his new analyser. Using Clifford's method of wrapping the curve round a cylinder, he saw that by imparting a simple harmonic motion to a plane tangential to the cylinder, which plane carried an Amsler planimeter whose tracing point followed the intersection of the plane with the curve, as the cylinder rotated, any coefficient A_n or B_n could be determined. This arrangement had considerable friction, and only gave one coefficient at a time; it also necessitated readjustment of the period of the harmonic motion for each pair of terms. Another machine founded on integration by parts was then constructed, in which the relative periods of cylinder and registering wheels was adjusted by a disc and roller, the motion being transmitted to the wheels by bands driven from the disc spindle. This gave A_n and B_n at one operation. Mr. A. Sharp used this machine for some time and then designed an inversion of it, in which the curve was laid out flat and the machine rolled over it. This arrangement greatly facilitated the multiplication of registering wheels, and thereby enabled several pairs of coefficients to be determined at once. The first machine of this kind showed several small errors which were avoided in a second instrument, a specimen of which, made by Coradi, was exhibited and described. A rectangular frame carried on three rollers (two being fixed to the ends of a long axis) traverses the paper in the direction of y, and the tracing point is fixed to a carriage which moves on the frame in a direction perpendicular to y, *i.e.* in the direction of θ. A band is attached to this carriage and imparts a motion proportional to θ to two horizontal axes (one for the A coefficients, and one for the B's), placed above and parallel to the long roller axis above mentioned. Each of the two axes carries five pinions having teeth in the ratios 1, 2, 3, 4, 5, respectively, which gear with crown wheels fixed to vertical spindles. The latter, therefore, rotate through angles proportional to θ, 2θ, 3θ, 4θ, and 5θ. To the lower ends of these spindles horizontal rings are attached, in which the bearings of a registering wheel are formed; each wheel rests on a cylinder carried by the long axis, and rolls or slides thereon according as its axis is parallel or perpendicular to that of the cylinder. Moving the tracing-point once round the curve gives five pairs of coefficients. By changing the driving-band to other pulleys so as to turn the pinions at different rates relative to the θ movement, the 6th, 8th, 10th, and 7th and 9th pairs can be determined. The chief drawback of the instrument is that the registering wheels are not easy to read, whilst the back-lash of the crown wheels and pinions introduces small errors. In the latest form of instrument toothed wheels are dispensed with, and glass spheres carried in frames on the vertical spindles roll on the horizontal cylinders; each sphere actuates two registering wheels on fixed areas at right angles to each other, and these give respectively the sine and cosine coefficients. The number of vertical spindles is therefore halved, and the instrument greatly simplified. These details have been introduced by Coradi. A working drawing of another analyser, designed by Mr. Sharp, which gives the amplitude and epoch of the curve resulting from each pair of terms in Fourier's expansion, was exhibited. The discussion on Prof. Henrici's communication was postponed until next meeting.—Mr. H. Wilde, F.R.S., then exhibited and described his "magnetarium." This consists of a hollow geographical globe, wound all over the inner surface with insulated wire in planes parallel to the equator. Within this globe is a sphere wound with wire on its surface, and having its axis inclined at 23½° to that of the outer globe. By means of epicyclic gearing the spheres can be made to rotate at slightly different rates. When electric currents of suitable strength are passed through the two windings, the magnetic condition of the earth can be imitated, both as regards distribution at any epoch, and the secular variations. A better result was obtained by putting sheet iron over the land areas, and a still closer approximation by using thin iron over the water areas. A magnetic chart and tables giving the magnetic elements at various places for different epochs as determined by the magnetarium were shown. The author mentioned that recent observations by the United States Survey at Ascension Island, and by Prof. Thorpe in Senegambia, had confirmed results obtained by his instrument. The President said he had tried the apparatus, and found the Siberian oval closely imitated. The secular variations at Greenwich were also well shown. In South America the approximation was not so good. In reply to a question by Mr. Blakesley, Mr. Wilde said the present position of the pole of the inner sphere was 84° W., 67° N.

Geological Society, March 7.—Dr. Henry Woodward, F.R.S., President, in the chair.—The Secretary announced that a portrait of the late Sir Richard Owen had been presented to the Society by Mr. Ernest Swain.—The following communications were read:—The systematic position of the Trilobites, by Mr. H. M. Bernard. The author, in his work on "The Apodidæ," endeavoured to show that *Apus* was the ancestral form of all existing crustacea except the ostracoda,

and as such might be expected to throw light upon the trilobites. Since the publication of this work he had been studying the organisation of the trilobites themselves, and the results were given in the present communication. He discussed the great variability in the number of segments shown by the trilobites; the formation of the head by the gradual incorporation of trunk-segments; the bending round ventrally of the first segment; the "wandering" of the eyes; the existence and modification of the "dorsal organ"; and especially the character of the limbs. As a result of this discussion, he stated that the zoological position of the trilobites can now be fixed with considerable probability. The features described serve to connect the trilobites with *Apus*. *Apus* must be assumed to lie low in the direct line up from the original annelidan ancestor towards the modern crustacea, and the trilobites must have branched off laterally from this line, either once or more than once, in times anterior to the primitive *Apus*, as forms specialised for creeping under the protection of a hard imbricated carapace, obtained by the repetition on every segment of the pleuræ of the head-segments, which together form the head-shield. The trilobites may be briefly described as fixed specialised stages in the evolution of the crustacea from an annelidan ancestor with its mouth bent round ventrally, so as to use its parapodia as jaws. The President agreed with Mr. Bernard that the earlier trilobites presented forms with very numerous segments, but pointed out that the later ones showed signs of advance in having fewer free thoracic rings and a well-developed pygidial shield. He had always cherished the idea that the Isopoda might have branched off at some distant time from the Trilobita, and he drew attention to such points of structure as the pores in the free cheeks, which were present in such isopods as *Sphæroma* and *Serolis*, and in such trilobites as *Phillipsia*, *Griffithides*, *Ampyx*, and *Trinucleus*. The Rev. T. R. Stebbing agreed with the author in thinking that the trilobites have little connection with the isopods, though the resemblance was sometimes striking, and was often favoured rather than otherwise by the character and position of the eyes. Prof. G. B. Howes said that he believed the discovery of the terminal anus in the trilobite dealt the deathblow to the association of the trilobites with the arachnoid series. He believed that the facts and arguments brought forward by the author of the paper proved the trilobites to be crustacea, and fully justified their association with *Apus* as an early offshoot on the crustacean line. Mr. Malcolm Laurie also spoke, and the author replied.—Landscape marble, by Mr. Beeby Thompson. The Cotham stone is a hard, close-grained, argillaceous limestone with conchoidal fracture. The dark arborescent markings of the stone rise from a more or less stratified dark base, spread out as they rise, and terminate upwards in wavy banded portions of the limestones. In some specimens two "landscapes" are seen, one above the other, each rising from a distinct dark layer. The author described the microscopical and chemical characters of the rock, and its mode of occurrence, and discussed the explanations which have been put forward to account for its formation, especially that of Edward Owen, who in 1754 gave the first published description of the Cotham stone, and that advanced by Mr. H. B. Woodward in the *Geological Magazine* for 1892. He then proposed a new explanation to account for the formation of the rock, and maintained that its peculiar characters are due to interbedded layers of vegetable matter, which decomposed and evolved carbonic acid gas and marsh gas. This decomposition continued while several inches of new sediment were laid down, the result being that arborescent markings were produced along the lines taken by the escaping bubbles, and that the upward pressure of these gases, after their escape had been prevented by increasing coherence or greater thickness of the upper layers of sediment, caused the corrugations in the upper surface of the stone. He further discussed the composition of the stone, and described experiments which he made to illustrate his views. Mr. H. B. Woodward, Prof. T. Rupert Jones, Mr. F. A. Bather, and Mr. Monckton spoke upon the subject of the paper, and the author replied.—On the discovery of molluscs in the Upper Keuper at Shrewley, in Warwickshire, by the Rev. P. B. Brodie. Mr. R. B. Newton read a paper at the meeting of the British Association at Nottingham in 1893, on some lamellibranchs found at Shrewley by the author of the present paper and Mr. Richards. This paper gave details of the section where the shells were found, and their interest and importance were pointed out, no shells having been previously detected anywhere in the New Red Sandstone in this country.

Entomological Society, March 14.—Colonel Swinhoe, Vice-President, in the chair.—Dr. D. Sharp, F.R.S., exhibited a collection of white ants (*Termites*), formed by Mr. G. D. Haviland in Singapore, which comprised about twelve species, of most of which the various forms were obtained. He said that Prof. Grassi had recently made observations on the European species, and had brought to light some important particulars; and also that in the discussion that had recently been carried on between Mr. Herbert Spencer and Prof. Weismann, the former had stated that in his opinion the different forms of social insects were produced by nutrition. Prof. Grassi's observations showed this view to be correct, and the specimens now exhibited confirmed one of the most important points in his observations. Dr. Sharp also stated that Mr. Haviland found in one nest eleven neoteinic queens—that is to say, individuals having the appearance of the queen in some respects, while in others they are still immature. Mr. Haviland gave an account of the structure of some of the nests, and stated that two of the species of white ants exhibited certainly grow fungus for their use, as described by Smeathman, many years ago, in the *Philosophical Transactions*. Mr. H. Goss remarked that the fact that the different forms of social insects were produced by nutrition was known to Virgil, who referred to it, and to the subject of parthenogenesis in bees, in the "Georgics," book iv. Mr. McLachlan, Colonel Swinhoe, Mr. Champion, Mr. Jenner-Weir, and Dr. Sharp continued the discussion.—Mr. O. E. Janson exhibited specimens of *Dicranocephalus adamsi*, Pascoe, from Sze-chuen, Western China, and *D. dabryi*, Auz., recently received from the neighbourhood of Moupin, in the same district; he observed that, although the latter had been quoted by Lucas, Bates, and others, as a synonym of *adamsi*, the two species were perfectly distinct; the females of both were unknown to the authors when describing them, and presented a remarkable difference.—Mr. C. O. Waterhouse exhibited, for Mr. E. A. Waterhouse, a specimen of *Colias edusa* resembling *C. erate*, a continental species, which was taken on Wimbledon Common; a varied series of *Chrysophanus phlæas*, from Barnes Common; and a series of *Lycæna arion*, from Cornwall.—The Rev. Canon Fowler read a paper entitled "Some New Species of *Membracidæ*."—Mr. F. Merrifield read a paper entitled "Temperature Experiments in 1893, on several Species of *Vanessa* and other Lepidoptera." He said that the results tended to confirm Dr. Dixey's conclusions as to the origin of the wing-markings in the *Nymphalidæ*, brought out many ancestral features, and in some cases were very striking. There was much difference in sensitiveness between the seasonal broods of the same species, even in *V. c-album*, although both broods of that species passed the pupal state in the warmer part of the year.—Dr. Dixey read a paper entitled "On Mr. Merrifield's Experiments in Temperature-variation as bearing on Theories of Heredity," which was supplemental to the previous paper. Colonel Swinhoe, Mr. Hampson, Mr. Jenner-Weir, Mr. Merrifield, and Dr. Dixey took part in the discussion which ensued.

Linnean Society, March 15.—Prof. Stewart, President, in the chair.—Mr. Clement Reid exhibited some cones of Scotch fir, and also some carbonised pine wood from a peat moss at Parkstone, Dorset. He said the pine had become extinct in the South of England after Neolithic times, and had been reintroduced only recently. Its extinction was commonly supposed to be due to forest fires. He found that every piece of pine wood imbedded in the peat moss was similarly charred, while portions imbedded in sand were little altered, and he suggested that the appearance of burning might possibly be due to the action of the growing peat, and have nothing to do with fire. A discussion followed, in which Messrs Carruthers, Hanbury, Christy, and others gave reasons for adhering to the older theory. Mr. Carruthers exhibited a diagrammatic table showing an accurate counting of the annual rings of growth in three gigantic specimens of Wellingtonia, *Sequoia gigantea*, from which he calculated the age of the trees (see p. 507). A section of one in the British Museum (Natural History), fifteen feet in diameter, which was a living tree when cut down, he estimated to be 1330 years old. As illustrative of the size to which these trees grow, he mentioned that he had measured two in America, one of which was 92 feet and the other 77 feet in circumference. A discussion followed on the conditions which accelerated or retarded growth, and Mr. G. Murray, in reply to a suggestion of Mr. Reid, pointed out that a number of experiments had

been made on various trees to test their rate of growth under different conditions of weather and temperature, but that the results varied to such an extent as to afford no basis for sound conclusions. Mr. A. B. Rendle exhibited the fruit of *Melocanna bambusoides* from the Mauritius, where it had been introduced, and gave some account of its structure and mode of growth, referring to the figure of it given by Roxburgh in his "Plants of the Coast of Coromandel" (pl. 243), under the name *Bambusa baccifera*.—Mr. C. B. Clarke gave the substance of a paper "on certain authentic *Cyperaceæ* of Linnæus," describing the results of his examination of the type specimens in the Linnean Herbarium, with suggestions for some rectifications in the nomenclature. Referring incidentally to the history of this Herbarium, he regretted the additions which had been made to it since the death of Linnæus, and the introduction of plants which Linnæus had never seen. In the discussion which followed, Mr. Carruthers and Mr. Daydon Jackson explained under what circumstances these additions had been made, and showed that it was antecedent to the collection coming into the possession of the Society, since which time no alteration in its condition had taken place.—Mr. George Brebner read a paper "on the development of the mucilage-canals of the *Marattiaceæ*," in which, with the aid of some excellent lantern slides, he showed that these canals are schizogenous intercellular spaces arising from the separation of cells, and are lined by a persistent epithelium. The secretion is thus the product of the activity of living cells, and not the result of cell-degradation. An interesting discussion followed, in which Dr. D. H. Scott, Prof. Reynolds Green, and others took part, and the meeting adjourned to April 5.

Zoological Society, March 20.—Prof. G. B. Howes in the chair.—The Secretary exhibited and made remarks on a photograph of a young male Indian bison (*Bos gaurus*), proposed to be sent home as a present to the Society's menagerie by Major G. S. Roden.—Mr. F. G. Parsons read a paper on the myology of the Hystricomorphine and Sciuromorphine rodents, and stated that it was based on the dissection of the muscles of examples of twenty-one species of rodents, belonging to many families of the Hystricomorpha and Sciuromorpha, made at the Society's gardens. The results of these dissections had been compared with the writings of other observers, and arranged, firstly under the heads of the different muscles, and secondly under those of the different families. The arrangement of the muscles coincided in a marked manner with the usual classification of the order, and seemed to depend much more upon the affinities of the animals than upon their habits and mode of life. The muscles which seemed most characteristic of the two principal sections were the masseter, the long flexors of the foot, the sterno-scapular, and the digastric. Three genera of the *Dipodidæ* had been examined, and were found to resemble the Hystricomorpha in many respects, while in others they approached the Sciuromorphine type.—A communication was read from Babu Ram Bramha Sanyál, containing remarks on a rare carnivorous mammal of Borneo (*Cynogale bennetti*), based on a specimen living in the Zoological Gardens of Calcutta.—A communication was read from Dr. R. W. Shufeldt, containing an account of the osteology of certain Cranes, Rails, and their allies, with remarks upon their affinities.—A communication was read from Mr. O. V. Aplin, containing field-notes on the Mammals of Uruguay, made during his recent expedition to that country.

Chemical Society, March 1.—Dr. Armstrong, President, in the chair.—The following papers were read:—The aerial oxidation of terpenes and essential oils, by C. T. Kingzett.—The amides of sodium, potassium, and lithium, by A. W. Titherley. Sodamide, $NaNH_2$, is obtained as a white crystalline mass by passing ammonia over sodium at 300°-400°; no sodium nitride, Na_3N, or disodium amide, Na_2NH, could be prepared. Potassamide, KNH_2, is similarly prepared, and sublimes at 400°. Lithamide, $LiNH_2$, is obtained in the same way, and has similar properties to the sodium and potassium amides.

Quekett Microscopical Club, March 16.—Mr. A. D. Michael, Vice-President, in the chair.—The secretary said they had received a donation which required something more than a formal acknowledgment. As members were aware, the club's collection was undergoing revision, and Mr. Morland, who had undertaken the Diatomaceæ, had presented a series of thirty-seven slides to replace others found to be bad or wanting. A special vote of thanks to Mr. Morland was carried unanimously. The chairman, on behalf of the subscribers, presented Mr. F. A. Parsons with an address and a valuable gold watch, as a testimonial to his zealous endeavours as secretary of the excursions sub-committee, during the last ten years, to make the gatherings a success. Coupled with these was a special series of pond-life, prepared and presented by Mr. C. F. Rousselet. Prof. Edlinger's photographic and drawing apparatus, made by Leitz, was exhibited by Mr. C. L. Curties.—Messrs. Swift exhibited and described their new biological microscope, which had the posterior limb of the tripod doubled and rotating on a pivot, thus giving increased steadiness to the stand, and at the same time enabling it to be packed in a smaller case. It was explained that the pivot was provided with a strong spiral spring, which would prevent it becoming loose, and also take up any wear at the bearing surfaces.—Mr. E. M. Nelson's paper on "the determination of the foci of microscopical objectives; lantern and camera lenses by arithmetical formulæ," was taken as read.—Mr. H. W. King read a paper on "Amœba." A discussion ensued, in which Mr. J. D. Hardy, the chairman, and the author took part.

CAMBRIDGE.

Philosophical Society, March 12.—Prof. J. McK. Hughes, President, in the chair.—Dr. W. H. R. Rivers showed apparatus devised by Prof. Hering to illustrate (1) colour-blindness of peripheral retina; (2) mirror-contrast; (3) influence of strength of illumination and of contrast on quality of colour; (4) diagnosis of colour-blindness.—Mr. J. C. Willis exhibited a plant of *Deherainea smaragdina* in flower. The flowers are interesting on account of their green colour, their large size and disagreeable smell. They are extremely protandrous. In the early stage the extrorse anthers completely surround and hide the stigma; later on the stamens bend away and come to rest on the corolla, and the flower is now female. From its colour scent, &c. it is probably adapted to large flies.—Notes on the Bunbury Collection of Fossil Plants, by Mr. A. C. Seward. Attention was called to the exceedingly interesting and representative collection of fossil plants recently acquired by the Botanical Department through the generosity of Lady Bunbury. Among the plants exhibited at the meeting were several type specimens from the coal-measures of the Sydney coal-field, Cape Breton; also some figured specimens from English rocks of Carboniferous and Jurassic age. One of the Jurassic species, *Pecopteris exilis*, Phill. was briefly described, and it was pointed out that Sir Charles Bunbury's account of this plant and his figure of the sporangia was entirely supported by a re-examination of the figured specimen. The generic name of *Klukia*, recently instituted by Raciborski for certain species of Mesozoic Schizaceous ferns, was therefore preferable to the older provisional genus *Pecopteris*, originally adopted for this Jurassic species.—Note on the liver-ferment, by Miss M. C. Tebb. By extraction with glycerin Claude Bernard obtained from liver a ferment which converted glycogen into sugar, but the properties of this sugar were not described. In the present research it was found that pig's liver, rapidly dried, produced dextrose when allowed to act on starch or glycogen. In all cases whether an extract or the dried tissue itself was used, the product of the action on starch or glycogen always gave crystals of phenyl glucosazone with phenyl hydrazin, and the reducing power increased *only slightly* on boiling with acid; hence the conclusion was drawn that one product of the action is *dextrose*. As far as they have gone, experiments with fresh liver have yielded the same result.

DUBLIN.

Royal Irish Academy, February 25.—Dr. J. K. Ingram, President, in the chair.—A paper was read by the Right Rev. Dr. Graves, on the discovery in the south of Ireland of a stone with a most perfect Ogham inscription.—Mr. Henry Dixon read some notes on the peculiar method of the development of the axillary buds of *Vanda teres*. The buds in developing break through the lower part of the petioles, and appear below the laminæ of the subtending leaf opposite to the lamina of the leaf next below it. This manner of development was also found in *Dendrobium ærides* and several species of *Vanda*. The chains of cells, with siliceous bodies found accompanying the sclerenchymatous fibres of the bundles in many Monocotyledons, were detected in the leaves but not in the stem of this orchid. The development of these cells was found to be

the same as that described by Prof. Strasburger in *Cocos flexuosa*. In tracing the outer stem bundles downwards, one occasionally was found to end in the woody fundamental tissue of the stem without fusing with another from a lower leaf. In the cylindrical leaf of *Vanda teres* the bilateral symmetry characteristic of most leaves was replaced by an imperfect radial symmetry; the upper surface of the leaf is, however, represented by a longitudinal groove in the lamina. In *Dendrobium teretifolium* almost perfect radial symmetry was found, the upper surface being represented by a canal running axially down the leaf; the walls of this canal for the greater part of its length are in close apposition, and are lined with epidermal cells, having a strongly marked cuticle. The development of this leaf was found to correspond with that of *V. teres*, except that the collar of tissue from which it arises enlarges uniformly, and not, as in *V. teres*, mostly on that side on which the lamina stands. The leaf in *Brassavola Hadweni* is an interesting connecting link between that of *Dendrobium teretifolium* and *Vanda teres*; the distal portion of the leaf is circular on cross-section, lower down a deep groove represents the upper surface, while at a still lower point the sides of the groove fused over it and the groove becomes a "canal" passing obliquely inwards into the leaf, till it finally occupies an almost axial position. The memoir was illustrated by a large series of drawings representing the various structures referred to, and a selection of these, of which photographs had been made, were thrown on the screen. Both papers were referred to the Council for publication in the *Proceedings* of the Academy.

PARIS.

Academy of Sciences, March 19.—M. Lœwy in the chair.—The death of General Favé was announced by the President.—An apparatus illustrating the horizontal movements in walking, by M. H Resal.—On intestinal absorption and the lacteals of the rat, by M. L. Ranvier.—Observations of the planets 1894, AX Wolf, AY Wolf, AZ Courty, BA Charlois, made at Toulouse Observatory (Brunner equatorial), by M. E. Cosserat.—Observations of the new planets BB (Charlois, Nice, March 8) and AX (Heidelberg, March 1), made at Lyons Observatory by M. G. Le Cadet.—On the variations of the Peltier effect produced by magnetisation, by M. L. Houllevigue. A theoretical consideration of the cases of iron and bismuth longitudinally and transversely magnetised and nickel longitudinally magnetised, with copper as the second element of the couple. The equation $V_T = \int \phi (T_1 M)\, dT$ furnishes a general solution of the problem "to find, at any temperature T, the difference of potential between a soft metal and the same metal in a field M," which the author is examining experimentally.—New method of studying electric convection in gases, by M. N. Piltchikoff. A point discharge is directed on to the surface of castor oil, and the depression of this surface studied under varying conditions.—Application of the vectorial method to the study of apparatus giving intermittent secondary currents, by M. A. Blondel.—The *monochromatoscope*, a new apparatus, by M. Maurice de Thierry.—On the general law of the solubility of normal substances, by M. H. Le Chatelier. A mathematical paper in which one of the deductions is as follows: If latent heat of solution were independent of temperature and concentration, the normal curve of solubility of any given substance would be the same in all solvents.—On a new automatic apparatus for measuring simultaneously the weight and volume of liquids, by M. Louis Bedout.—On the molecular weight of ferric chloride, by M. P. Th. Muller. The raising of the boiling points of alcohol and of ether by dissolved ferric chloride show that the molecular weight at the boiling point of alcohol is represented by the formula $FeCl_3$; in the case of ether solutions, the molecular weight diminishes with the increase in dilution.—On the composition and heat of formation of the hydrate of nitrous oxide, by M. Villard. The composition of this substance corresponds to the formula $N_2O.6H_2O$. Two determinations of its heat of formation gave 77·84 cal. and 77·76 cal. for 1 gram of water.—On thallium hypophosphates, by M. A. Joly. The salts $Tl_2H_2P_2O_6$ and $Tl_4P_2O_6$ are described. The latter decomposes with liberation of heat when heated to 250°; $Tl_4P_2O_6 = 2TlPO_3 + 2Tl$.—On the distribution of strains in metals under stresses, by M. F. Osmond.—On β dibromopropionic acid, by M. R. Thomas Mamert. $CHBr_2.CH_2.CO_2H$ is obtained by the action of fuming hydrobromic acid on $CHBr:CH.CO_2H$ at 100°. It melts at 71°.—On the influence of the method of distribution of manures on their utilisation by plants, by M. A. Prunet.—Researches on the pathology of pancreatic diabetes, by M. M. Kaufmann.—The glucose formation exciting nerves, by MM. Morat and Dufourt.—On the anal sacs of Ophidians, by M. Portier.—Anatomy of the trachean system of the larvæ of Hymenoptera, by M. Bordas. This system may be represented as formed by two long lateral parallel cylinders, giving off numerous transverse branches, united anteriorly by a large trunk, and posteriorly by two unequal branches forming a perirectal ring.—On the degeneration of the genital products among the Polyclinidæ, by M. Caullery.—Bacillary maladies of several plants, by MM. Prillieux and Delacroix.—On *Pterophyllum*, by M. B. Renault.—On the gabbros and amphibolites of the bed rock of Belledonne, by MM. L. Duparc and A. Delebecque.—The *tectonique* zones of the Alps of Switzerland and Savoy, by M. Emile Haug.—Researches on mud overflows, by M. Stanislas Meunier.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Life and Rock: R. Lydekker (Universal Press, High Holborn).—The Microscope and Microscopical Methods: Prof. S. H. Gage, 5th edition (Ithaca, New York).—A Standard Dictionary of the English Language, Vol. 1 (Funk and Wagnalls Co.).—Introduction to the Mathematical Theory of the Stress and Strain of Elastic Solids: Dr. B. Williamson (Longmans).—The Outlines of Quaternions: Lieut.-Colonel H. W. L. Hime (Longmans).—Everybody's Guide to Gardening: H. H. Warner (Saxon).—Perennial Irrigation and Flood Protection for Egypt (Cairo).

PAMPHLETS.—Hand-Guide to the Royal Botanic Gardens, Pérádeniya: H. Trimen, 4th edition (Colombo).—Die Magnetischen Localabweichungen bei Moskau, &c.: Dr. H. Fritsche.—Report on the Operations of the Department of Land Records and Agriculture, Madras Presidency, 1892-93 (Madras).

SERIALS.—Timehri. December (Stanford).—Beiträge zur Geophysik, 2 Band, 1 Heft (Stuttgart).—Astronomy and Astro-Physics, March (Wesley).—Natural Science, April (Macmillan).—Geographical Journal, April (Stanford).—Morphologisches Jahrbuch, 21 Band, 1 Heft (Williams and Norgate).—Transactions of the Astronomical and Physical Society of Toronto for 1893 (Toronto).—The American Antiquarian and Oriental Journal, November (K. Paul).—Humanitarian, April (Sonnenschein).—Epsom College Natural History Society Report for Year 1893 (Holmes).

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